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A MONTHLY RECORD of the PROGRESS of CIVIL and MECHANICAL ENGINEERING

ESTABLISHED 1843.

EDITED BY
PETER SOAMES A.K.C.
M.I.C.E.

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SHIPBUILDING, STEAM NAVIGATION, THE APPLICATION OF CHEMISTRY TO THE INDUSTRIAL ARTS,

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EDITED BY PETER SOAMES, A.K.C., C.E.

Vol. IV.
FOURTH SERIES.

Vol. XXVIII.
FROM THE COMMENCEMENT.

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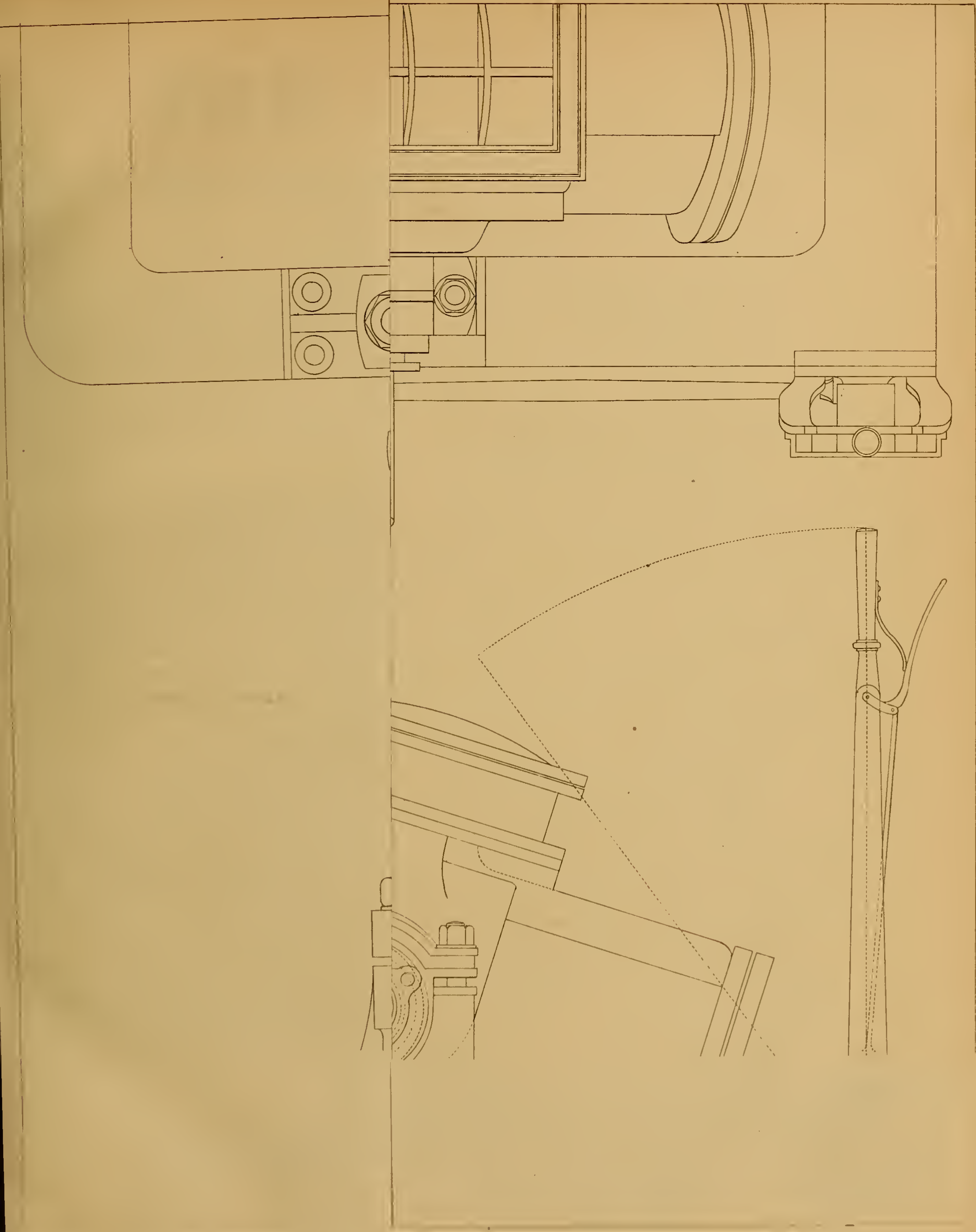

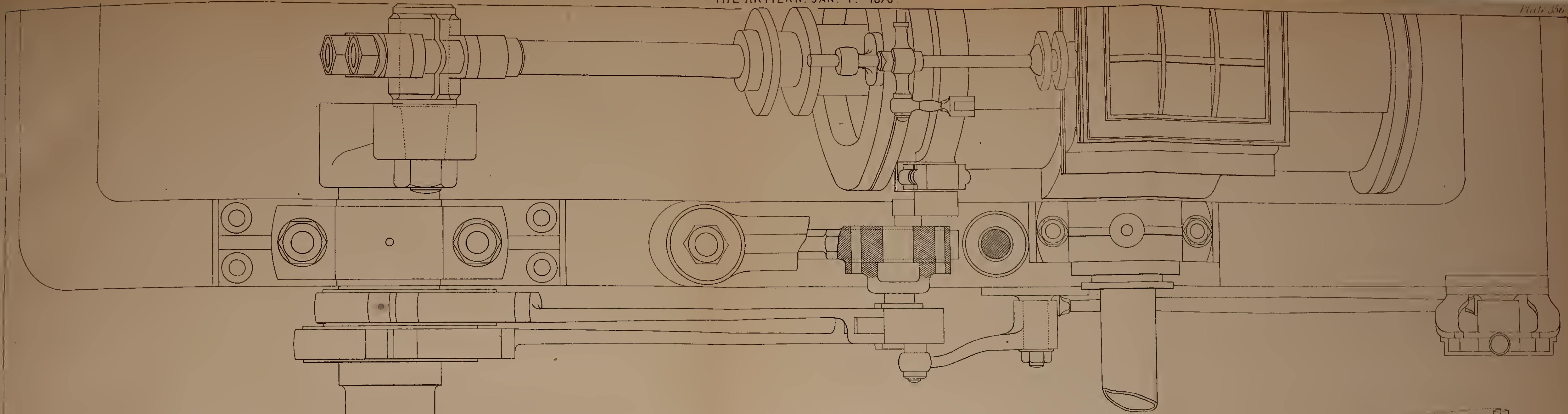

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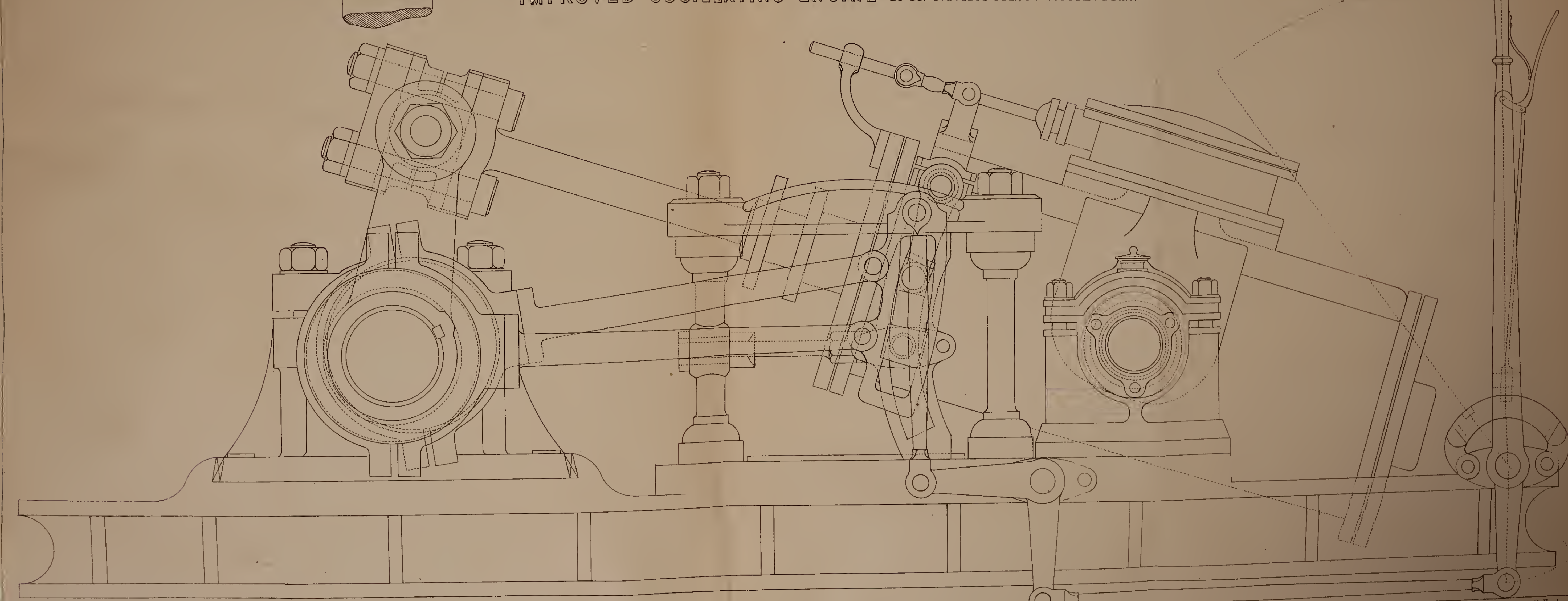


W. Smith C.E. direx

THE ARTIZAN.

No. 1.—Vol. IV.—Fourth Series.—Vol. XXVIII. From the Commencement.

1st. JANUARY, 1870.

"THE ARTIZAN" ADDRESS.

In the address to our readers which appeared in The Artizan just twelve months ago we began by regretting the extraordinary and long continued depression in all departments of engineering, and, moreover, were unable to anticipate with any confidence a speedy return to general activity. The year that has just passed has unfortunately proved too truly the general correctness of such gloomy anticipations, although in some departments—such as shipbuilding in the North—there has been considerable improvement.

Notwithstanding this almost universal stagnation in new projects, the past year has seen the ostensible completion of two of the greatest—if not the grandest—engineering feats ever accomplished; we allude to the Suez Canal and the Atlantic and Pacific Railroad. We can also chronicle the completion of several important works nearer home, such as the Blackfriars Bridge, the Holborn Viaduct, the French Atlantic Cable, the Tower Subway, the Albert Dock at Hull, and various other almost equally important works. With regard to the Suez Canal, although it has certainly been opened with all the pomp and ceremony of an Eastern undertaking, it cannot be considered nearly completed, and although many light draught vessels have passed through, it is doubtful whether it will be generally available for traffic for a considerable time to come. We think it is much to be regretted that those whose business is to know the exact state of the canal have either been so reticent, or have put forth such inflated statements, that it has been left to a few independent soundings by private individuals to supply anything approaching to reliable data. From these, we gather that there is sufficient depth of water to permit a vessel drawing sixteen feet to pass through, or about two-thirds the proposed draught; it is evident therefore that a considerable amount of dredging will have to be done before it becomes available for the majority of steam-vessels at present passing along the Red Sea. The banks also are at present very much too steep, and will require a large amount of labour and money expended upon them either for the purpose of pitching their sides, or, what would be much simpler, reducing the slope. Besides want of water there are several minor difficulties to be encountered, such as rounding the bends in the canal, and the influence of a side wind, which latter appears to be rather serious. Thus, a vessel necessarily travelling at a slow speed will be obliged to keep in a slanting position across the canal, the head being up to windward to make up for leeway, and by so doing she must take up a considerable portion of the width of the canal. A long ship—such for instance as are at present being built in the North for this trade—travelling in this manner might have considerable difficulty in passing another long vessel steaming in the opposite direction, similarly situated, and consequently slanting at an equal but opposite angle. It is not our province to speculate upon the commercial features of this immense undertaking, but we fear it must be a long time before that unfortunate individual, the original shareholder, will derive any substantial return for his outlay. As regards the amount of traffic that may be expected, opinions seem to be very much at variance. Upon an examination of the wind charts it will be evident that sailing vessels would derive no advantage from the canal even when bound for the west coast of India; it remains therefore to be seen how far steam vessels travelling through it can successfully compete with sailing vessels going round by the Cape. For trade with India it would appear that steam vessels using the canal would have the advantage over sailing vessels going by the longer route, for the carriage of almost every description of merchandise. For valuable cargoes, such as tea and silk, it is also probable that the canal will be found the most advantageous route, but it is not likely that the owners of sailing vessels will give up this trade without a most determined fight. For the passenger traffic the canal will be a great boon in every way to the travellers themselves. The unpleasant and tedious journey from Alexandria to Suez, with its enormously high charges, to which is added the delightful uncertainty as to how long one may be obliged to stop at an expensive hotel at one's own expense, will be avoided. The nuisance of having to shift one's cabin, with the possibility of discovering during the night that the blow-off pipe runs just under one's head, will also be avoided. But perhaps the greatest advantages derived by travellers will be a great reduction in the enormously high fares; as it is evident that the great increase in the number of steam vessels will speedily crush the present monopoly.

The other great engineering work already mentioned—the Atlantic and Pacific Railroad—may, in a certain sense be considered as finished, but from all the accounts we have received it appears that a large portion of it has been so roughly executed that it will most probably have to be re-made. It has not yet been opened a sufficient period to form a reliable estimate of its safety, or of its reliability, but probably the present winter will afford some illustrations of the uncertainty of the journey from New York to San Francisco. It must be acknowledged, however, that both the idea and the execution of such an enormous length of line, a large portion of which presented difficulties of no ordinary nature, are worthy of even such a go-ahead nation as the Americans; and whatever shortcomings that may at present exist, will, doubtless be remedied as occasion requires.

With regard to the large engineering works at home, but little need be said as they have already been described in The Artizan. Blackfriars Bridge, which since its formal opening in November, has been dressed out in dark green and gold, certainly looks very imposing, and is well worthy the high reputation of its designer, Mr. Joseph Cubitt. It always appears to us to be a great pity that such a grand bridge with its splendid width of roadway and footway, could not exchange places with

London Bridge, which is in a chronic state of congestion. A proposal, has, we understand, been submitted to the authorities for widening London Bridge, by lengthening the present granite cutwaters, and throwing across iron arches similar in shape to the present granite arches. By this means it is said that except from the underneath, the appearance of the bridge will be kept exactly the same; we confess, however, that we are quite unable to understand how such a desirable result is to be accomplished.

Of the Holborn Viaduct we can have but little to say, except that it is a remarkably handsome piece of architecture. The unfortunate oversight, which has been the cause of destroying the beauty of several of the granite columns, is still under the consideration of three of our most eminent engineers, and their decision will doubtless be published in a short time. The French Atlantic Telegraph Cable, may also, we think, be termed a grand engineering feat, both for its wonderfully perfect construction and equally perfect success in laying; for the excellence of the construction great credit is due to Mr. Henry Clifford, engineer to the Telegraph Construction and Maintenance Company; while to the skill of Sir Samuel Canning, the successful laying must be chiefly atrributed.

Of all the civil engineering works completed this year, the Tower Subway carries off the palm for ingenuity and economy; an account of which has recently been given in The Artizan. Since that time we have heard that the fares are to be threepence first-class and twopence second-class, but we presume that such high fares are merely intended to last so long as a trip along the Subway is regarded as a curiosity.

In mechanical engineering, the most interesting, and perhaps the most important, novelty of the year is Morton's ejector-condenser, a plate and description of which was given in The Artizan of January. For land engines and for river steamers it appears to be admirably adapted, being much simpler, lighter, and occupying less room than the common condenser. As a means of applying the principle of condensation to high pressure engines already in existence it would be very valuable, especially in many foreign countries, where, from the difficulties of transport, lightness of each separate part of an engine forms an important item. In The Artizan of last month an account of some interesting experiments, made upon a high pressure engine fitted with the ejector-condenser, by Professor Rankine, were given, in which it appeared that a saving of about 30 per cent. was effected by its use. The importance of saving anything nearly that amount where fuel is expensive—such, for instance, as in most sugar-growing countries—is self-evident, and we have no doubt that for such purposes it will be extensively adopted. A different, but almost equally ingenious, application of the same principle has been applied by Mr. James Robertson, of Glasgow, for the purpose of ejecting solid materials, such as ashes from a ship's hold, and sand for sinking foundations, a full account of which will be found in The Artizan for February last.

In shipbuilding there is scarcely any novelty to notice, with the exception perhaps of a very slow turning round of the Admiralty in favour of turret ships. It is so many years ago that this system was advocated in The Artizan, that we had long since despaired of such a reformation in our Navy; but we hope that the old adage, "better late than never," will prove applicable to this case. The shipbuilding trade on the Clyde and in the North of England has been very active, while the yards on the Thames have been almost entirely deserted. We wonder when the London workmen will understand their own interests, and consent to work at such a rate of wages as will bring at least a portion of the trade back to London again.

OSCILLATING ENGINE OF 10-HORSE POWER.

By Mr. J. J. Montyn, Jun., Rotterdam.

(Illustrated by Plate 356.)

One of the objections usually brought against oscillating engines is that the valve gear is either expensive or unsatisfactory, and, consequently, although it has fewer parts and works with less friction than almost any other description of engine, it has been almost entirely superseded by the more easily manufactured horizontal engine. The original plan of working the valve by the motion of the cylinder was, no doubt, remarkably cheap and simple; but, from the impossibility of giving any lead, it was only suited to such cases where economy of steam was of no consequence, such as working steam-cranes, and similar intermittent jobs. By the adoption of the eccentric and sweep this difficulty was overcome, but even then there was no provision for varying the expansion except by throttling the steam

In the engine illustrated by Plate 356, a very ingenious and at the same time simple arrangement of valve gear is shown, by means of which the engine may be worked at any grade of expansion, and which was designed by Mr. J. J. Montyn, jun., of Fyenoord, near Rotterdam. The plan and elevation of a 10-horse power engine here given is so explanatory in itself that but little description is required. It will be seen that the link here shown is worked in the usual manner, except that the eccentrics are connected to what may be termed only a half-link, being only adapted for stopping or for forward motion, but not for reversing. It is evident that by means of the hand lever the travel of the valve, and, consequently, the amount of expansion, may be varied to any required extent, in a precisely similar manner as the degree of expansion is regulated by the hand lever on a locomotive. Altogether, we think it is a very convenient arrangement for regulating the expansion in an oscillating engine by hand. We have only one suggestion to make, viz., that possibly Mr. Montyn's design might be made still more useful if he would devise some method whereby the governor would take the place of the starting-handle, thus changing it into a self-acting variable expansion gear.

DRESSING MILLSTONES BY THE USE OF THE DIAMOND.

The following description of one of the first, and, at the same time, one of the best millstone dressing machines upon this system, is taken from the *Scientific American*:—

Millers who may be unacquainted with the nature of diamonds or their durability, it is reasonable to suppose, will be somewhat sceptical and incredulous as to the practicability of using them successfully as an economical application in dressing the lands of millstones. But if they would take the trouble to investigate their history and the purposes for which they are, and have been employed, besides that of ornaments, they will learn that they were used before the Christian era, and up to the present age, for making lines of any depth or form, and for carving faces and figures in relief upon the hardest class of stones, such as the onyx, and others which are almost as hard as the diamond itself. Again, diamonds are now being used successfully for drilling, sawing, planing, turning, shaping, carving, and dressing stones or other hard substances.

Diamonds set in an ordinary stem or ferrule, were tried many years ago in Europe (and recently in this country) for producing lines upon millstones, and the millers were perfectly satisfied that the finest and most effective dress was attained by merely gliding the diamond lightly over the stone. The use of diamonds for this purpose was abandoned, however, from the difficulty in keeping them in their setting, and the liability of their being broken by over pressure. It was universally conceded, that if the diamond could be set sufficiently firm in an instrument, so constructed as to regulate the pressure and protect it, it would eventually in a great measure supersede the pick.

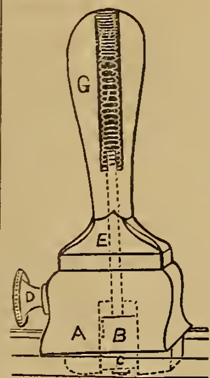
After many experiments and trials, Mr. Dickinson has succeeded in constructing the important improvements illustrated in our engravings, the success of which is attested by those using the machine for over six years. The main difficulty he found was in educating millers to the proper handling of the diamond, and overcoming prejudices against any innovation upon the old mode of dressing with a pick. From their habit of seeing so much stone displaced, it had become an idea, or conviction with them that such displacement was actually necessary or unavoidable, and it has taken some time to convince them of the contrary.

The large engraving represents Mr. Dickinson's patent graduated guide. A double rule, *A*, is connected to a straight edge, *D*, by two transverse arms *B* and *C*; the arm *C* having slots, *E* and *F*, cut in the centre and the right, hand end to accommodate the motion in drawing the arms in a direct line with each other toward the straight edge, *D*, which is done by the revolution of a small roller in a spiral cut in the wheel, *H*. This roller is screwed on a projection, *G*, attached to the middle of the lower arm, *B*. The wheel, *H*, has also cut on its edge graduated teeth in which a pawl, *I*, is made to catch, propelling the wheel around when actuated by the thumb-piece, *K*, with the pressure of the thumb of the left hand, and it is sustained in its position by a pawl, *L*, as the pressure is continuously repeated. The box, , contains a spring which throws the double rule, *A*, back to its former position when relieved from the pawl, *L*. On a raised ledging of the bed-late, *P*, there is a graduated scale with figures, to enable the operator to set his distances as he may require between each line, which is done by a short sliding bar secured by a screw, *G*. *O* is a raised ledging on the inner rule which guides and steadies the protector in its motion. The spiral movement described is attached to the bed-plate, *P* (the latter being planed level), and is adjustable upon the face of the stone as may be required.

In using this guide, the operation is very simple, and requires but little practice, the guide being so constructed as to produce the distances between each crack mathematically correct. It can also be set by the scale so as to obtain any number of cracks to the inch from eight to forty-eight.

When using this instrument the palm of the left hand is pressed firmly upon the bed-plate, P, on which the movement is fixed, and, after having marked with the diamond as often as required, the thumb-piece, K, is pushed by the thumb of the left hand as far as it will go, then immediately relieved.

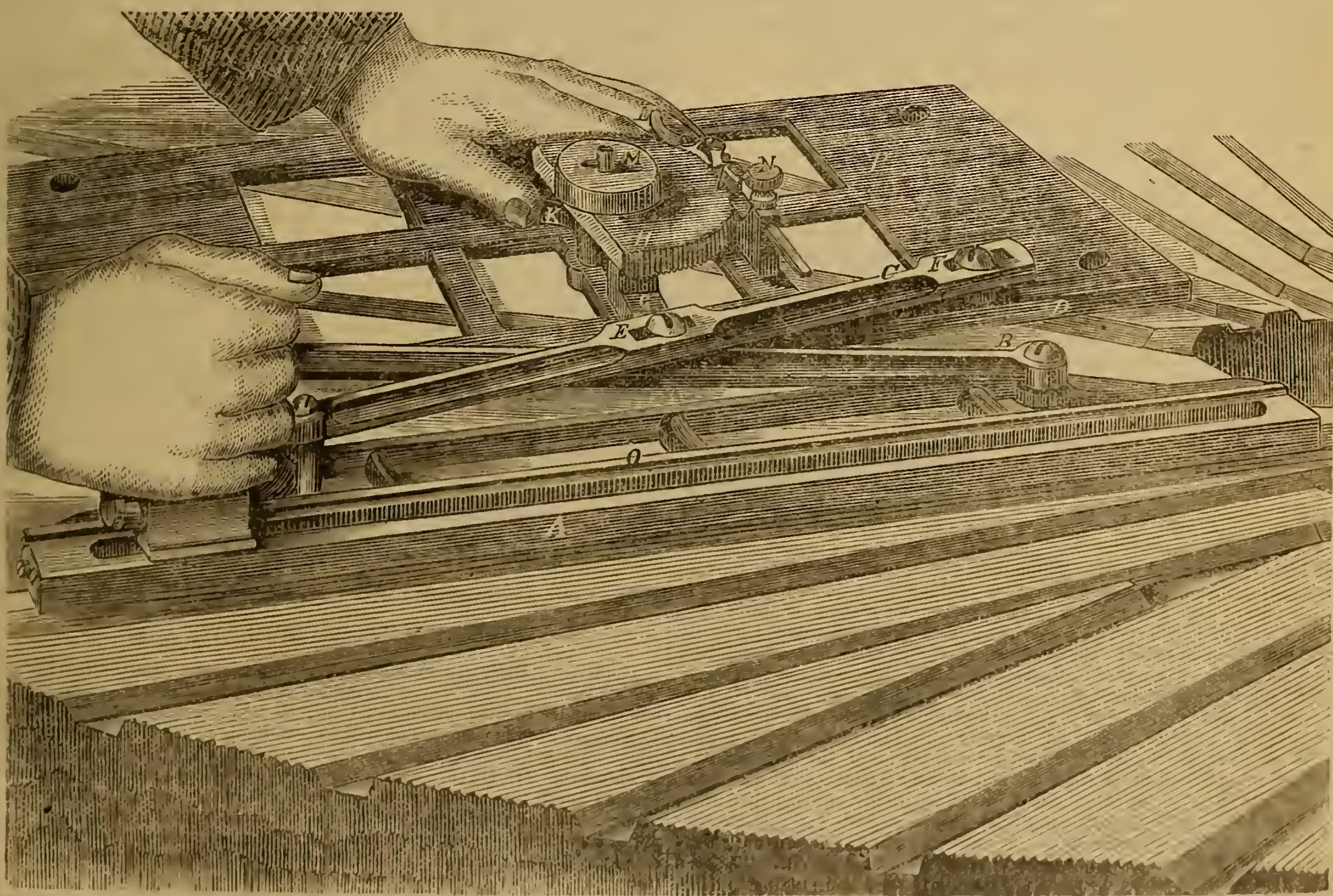
This pressure is repeated until the back of the double rule touches the straight edge, *D*, when the forefinger of the left hand presses the pawl, *L*, and the spring in the box, *M*, then instantly extends the double rule to its first position.



The small diagram shows the construction of the "protector." A represents the stock or protector in which is inserted a steel bar, B, containing the diamond, C. A is a shifting guard upon which the protector is made to slide between the double rule or tramway. This guard is adjustable and secured in its position by a thumb screw, D. E is a rod which is pressed upon the bar, B, containing the diamond, C, by a spring, which pressure is increased or diminished by a screw, H, at the top of the handle, G, in accordance with the nature of the burrs and depth of dress required.

This protector is drawn through the double rule or tramway, the same as a pencil in ruling a slate. The operation is so simple that a boy could operate with it blindfolded.

Any person of ordinary skill can dress a pair of burrs by following the directions. The lines produced upon the lands of a burr are fine, perfect in shape and regular on each edge, totally different from the cracks made by a pick, which are naturally coarse and irregular. In the usual mode the pick produces a stellated fracture, thereby weakening or disintegrating the stone as far as the fracture extends. Thus the edges of the crack, weakened by the blow from the pick, soon crumble away, wearing the face of the stone as the particles thus detached are thrown out.



The line cut by the diamond upon a glassy surface which has never been disintegrated by a blow from a pick is clear and distinct, having its edges sharp and fine, with no disposition to crumble, being perfect to the edge of the crack, thereby insuring a sharp corner or cutting edge perfectly straight and equal. Stones dressed after this mode, either hard or soft, open or close, will, it is claimed, run longer and perform a greater amount of work, and also will become more perfect as the bruises occasioned by the pick are emoved. It is not intended for dressing out the furrows.

There is no crushing contact of the stones with the wheat, the sharp edges of the cracks actually cutting, or shaving up the grain, although brought very close together. Stones running clear of each other produce a clear whistling sound, differing from that obtained by any other made of dress. On the starting of the stones they commence to do their work effectively, producing no middlings, and the flour comes from them with its nutritive properties unimpaired. There is no perceptible moisture generated in the operation of grinding, and much less power is required to produce a superior article of flour.

It is further claimed that after putting the furrows in proper order, the lands of the burrs can be kept so by the labour of from one to two hours every four days; and that burrs have been run satisfactorily with this dress over six days and nights without taking them up; and have performed half as much more with less power and in the same time.

It is claimed to be much easier to keep the burrs in face on this system. The use of the pick is entirely dispensed with, except in dressing the furrows and high glossy spots on the face, which must be taken off with a sharp pick.

Mr. Dickinson claims that by this method of dressing stones not less than three pounds more flour per bushel is obtained than is possible with the old dress, and of better quality, devoid of grit. The saving in labour, time of the mill, cost of picks, and quantity and quality of flour in the aggregate must be a very large item, sufficient in itself to constitute a difference between a successful and unsuccessful business. Without dispensing with the services of the operative millers, it will lighten their labours, and enable them to keep their burrs in good condition.

Many of these machines have been in use for six years, and have not cost more than £2 for diamonds and repairs.

THE HOLBORN VALLEY VIADUCT.

On the motion of Mr. Deputy Fry, chairman of the Improvement Committee, a letter was read from Messrs. George P. Bidder, T. E. Harrison, and Edwin Clarke, civil engineers, under date of the 10th ult. In it they refer to the Committee's minute of the 11th of November asking them to report in writing, at the earliest moment, whether the Farringdon-street bridge in their opinion was safe for public traffic, and secondly what in their judgment were the causes of the present defects in the columns, and the action it would be desirable to take with reference thereto. In pursuance of that request they had carefully examined the viaduct, and were of opinion that it is perfectly safe for public traffic. They had also carefully investigated the details of the plans and the instructions connected with the work, and had had explanations from Mr. Haywood, the engineer, from the two clerks of the works, and from the mason. They had come to the conclusion that their is no defect whatever in the foundations of the work. The defects which do exist are confined, they say, first to the stones at the top and bottom of the Ross of Mull granite shafts of the columns and to one of the castings forming the external arch over the footpath at the south-west corner of the viaduct, which has comparatively but little pressure upon it. The beds of the thin stones at the top and bottom of the shafts which are of Ross of Mull granite, and rather of a brittle nature were fine chiselled to a true bed for a depth of from 1½in. to 2in. all round their periphery—the centre of the beds being purposely left hollow—to an extent not exceeding one-eighth of an inch on each bed. The plan which was adopted in the setting of the columns was as follows:—After having fitting them independently before they were placed *in situ*, to ascertain their perfect truth, when they came to their permanent erection 12 pieces of 5lb. to 7lb. lead, varying from 6in. to 8in. square, were placed opposite all the exterior and interior angles of the columns, at a distance of one inch from the face, and in some instances it was stated that an additional piece of thin lead was added to give an equal bearing. The interior of that bed was then filled with fine mason's putty, consisting of lime and stone dust, and where hollows were found in the centre portions of the beds of the stones additional pieces of lead were put in. The beds were further adjusted by frequently lifting the stones and putting in additional mason's putty until every apparent inequality had been met. It would thus appear obvious that the main weight of the superstructure was resting primarily upon the pieces of lead placed near the outer edge of the beds. That mode was occasionally adopted in the erection of granite columns in situations to which they were ordinarily applied. But, inasmuch as in this case the superstructure is of iron, subject to expansion and contraction, and imposing on each column a weight of about 180 tons, the conditions to which the columns are subject are entirely different. The chisel dressing of the beds only extends from 1½in. to 2in. from the external edge of the column, the interior being picked slightly hollow. The result, therefore, undoubtedly was that an unequal bearing might be thrown on the lead packing, which approaches within an inch of the outer edge of the bed. The engineers had been informed that the iron work was put together in the summer months, and the final weighting would thus not have been completed until nearly the end of October or the beginning of November. The extreme difference of temperature between those periods might be taken at 50deg. Fahrenheit, and, as far as the engineers could ascertain, no defect whatever was observed till within a few days prior to the formal opening of the viaduct. It would therefore seem that those defects became apparent at about the period when the full weight was upon those stones, and when there would be the greatest difference in the temperature. The contraction due to that variation in the temperature would amount in the centre opening to about a quarter of an inch, or one-eighth of an inch at the head of each column; but there would be a materially reduced action at the base, and there would be a slight tendency to bring the weight unequally on a portion of the lead packing, and to occasion a high local pressure upon a very limited portion of the outer surface of the stones. That mode of setting was a departure from the instructions given by Mr. Haywood, and there was no evidence to show by what authority the original plan was departed from. The engineers had, from a careful consideration of the circumstances, arrived at the conclusion that the defects in the top and bottom stones of the shafts of the columns were to be attributed to the mode adopted of setting the granite on small pieces of lead packing and to the unequal diffusion of the weight thereby occasioned, combined with the fact that the base and cap stones are only twelve and nine inches thick respectively, and the whole effect was further aggravated by the tendency which the contraction of the iron superstructure in cold weather would have to throw an unequal pressure on the edges of the stone, through the medium of the lead packing. The engineers further state that they do not believe that any one of these circumstances would, taken by itself, have caused the existing defects. With respect to the imperfect casting on the south face of the viaduct, they had carefully examined some of the wedges against which the castings abut, and had found that they were solidly embedded in the brickwork. Therefore, as regarded the wedges, there was well-grounded reason to believe that no motion had occurred. There was an original defect in that particular casting previous to its erection, but it had been been repaired by bolting a plate of iron on the back; a recent crack had since been observed, but no importance was to be attached to it, as it might be the result of a further latent defect in the casting. Under these circumstances they (the engineers) could not recommend the Improvement Committee to do anything at present, except to fill up the cracks and interstices with a suitable composition, and to wait until the whole work had been exposed to the action of the extreme cold of the coming winter, and to the maximum heat of the next summer. It was possible that if a very severe lowering of the temperature should occur during the approaching winter some slight extension of the cracks might be observed, but nothing, in their opinion, that could endanger the safety of the structure. After twelve months' experience and another careful examination steps might be taken to remedy the most apparent defects, and to restore the work to its pristine beauty. In conclusion the engineers express their deep regret that a work of such magnitude and public importance should have sustained any blemish, and they bore their willing testimony to the efficient manner in which the works had been carried out, involving, as they did, an unusual amount of detail.

TRIAL OF H.M. CORVETTE "VOLAGE."

The trial of H.M. new unarmoured iron-built screw corvette the *Volage* was made on the 7th ult., over the measured mile, in Stokes Bay, near Portsmouth, under the supervision of Capt. E. Rice, commanding the Steam Reserve at Portsmouth. The officers conducting the trial under Capt. Rice comprised Messrs. G. Murdoch and J. Ward, chief inspectors afloat of machinery; Mr. Owen, assistant master shipwright; Chief Engineer Murray, and a number of subordinate officers. Mr. Crossland, chief draughtsman of the Department of the Constructor of the Navy, was also present as the Whitehall representative. The weather was unfavourable as regarded the greatest development of the ship's steaming powers, a strong wind prevailing from N.E. to E.N.E., which, in addition to its deteriorating influence upon the speed of the ship in its bearing upon the hull, masts, and yards, raised up a wave over the measured mile course which must have materially reduced the speed from the higher rate which certainly would have been reached under more favourable conditions of weather, and under the same conditions of efficiency of machinery. Upwards of 15 knots per hour is, however, a great speed for any ship over the measured mile, when taken as a mean rate from six consecutive runs. She, however, undoubtedly ought, as a war vessel, to approach nearer to the magnificent fighting powers of the *Inconstant* than her six 6½-ton guns place her. The difference in this respect between the two ships lies in the fact that the *Inconstant* carries the same upper deck armament as the *Volage*, with a main deck armament of 12 9-inch guns, for which the *Volage* has no equivalent. The *Volage* on entering upon her trial drew 16ft. 5in. of water forward, and 21ft. 5in. aft. This gave her a mean draught slightly in excess of what she will have when ready for sea. The actual weight she will have on board when placed in commission, and with all her stores, coals, crew, &c., on board, in readiness to leave Spithead on a term of foreign service, had been taken into calculation, and the equivalent—with 50 tons in excess—placed on board in the shape of iron ballast. The engines are of 600-horse power nominal, and drive a two-bladed Griffiths screw, fitted with lifting gear. The diameter of each cylinder is 93½in., and that of the trunk 36½in., giving an effective diameter of 86in. The stroke of the pistons is 3ft. 9in. The screw has a diameter of 19ft., and a pitch varying between 20ft. and 25ft. On the trial it was set at a pitch of 22ft. 6in. The engines in their design are of the usual trunk principle with surface condensers and superheaters. Mr. H. Anderson, of the firm of John Penn and Son, was on board and in charge of the machinery during the trial. The six runs made over the measured mile gave the *Volage* a mean speed of 15·105 knots per hour, the speed obtained on each run, with and against the wind and tide, being as follows:—Speed of ship odd numbers with the tide and wind, and even numbers against both—No. 1 run, 14·400 knots per hour; No. 2 run, 16·074 knots per hour; No. 3 run, 14·173 knots per hour; No. 4 run, 16·216 knots per hour; No. 5 run, 13·534 knots per hour; No. 6 run, 16·667 knots per hour. The mean speed of the ship on the Government measured mile was, therefore, 15·105 knots per hour. The next day the *Volage* was again taken out of Portsmouth and completed in her series of official trials, by running her over the measured mile in Stokes Bay, and in circles, under half boiler power. Her mean rate of speed was found to be 13·7 knots per hour, and her time in running over her circles was, to starboard, 6 min. 7 sec., and to port, 6 min. 14 sec. With full boiler power the time she occupied in making her circles was, to starboard, 5 min. 59 sec., and to port 5 min. 46 sec. The speed made by the *Volage* have proved greatly in advance of the estimated rate, especially at half boiler power, and give her the highest co-efficient in the navy, being no less than 457·2. She is a very buoyant ship, and as her coal bunkers are capable of being greatly enlarged, it is believed that she can be made to carry coal for steaming 5,000 miles at eight knot speed.

INDIAN PUBLIC WORKS DEPARTMENT.

It is well that at this juncture the constitution of the Indian Public Works Department should be thoroughly overhauled. With a current deficit, caused in great measure by unauthorised expenditure in public works, the Government of India is about to launch into some of the most gigantic undertakings in civil works ever taken in hand by any Government, and the tools with which it works should be carefully chosen and well tempered. Some few months back it was remarked with surprise that in prospect of these vast civil engineering works, the Secretary of State was sending out an unprecedented number of Royal Engineers. The philosophy of thus selecting costly military men to carry out civil works is supposed to be that "tone" is required, and that military habits of discipline and fidelity to duty are needed to bind together the vast and miscellaneous industrial army, which the Government of India must soon have under its command. So far, there is, from an Indian point of view, much to be said for the importance of "tone;" but there has been exaggeration in this direction. Offence has been needlessly given to civil engineers by publicly warning the whole profession, that when employed under Government, they must, like soldiers, be content with their pay. But it has been shown through the press, both at home and in India, that the pay, promotion, and other provision offered by the Indian Government to Civil Engineers entering its service by competitive examination are insufficient, and glaringly unequal in comparison with the aggregate pay and influence enjoyed by military engineers. This wide contrast cannot be permitted to endure, or the Royal Engineers will have to be much restricted in number compared with the whole strength of the department. India cannot afford public works the actual cost of which must be computed as including the military as well as civil pay of Royal Engineers. This is a consideration constantly overlooked in stating cost of our public works, but the item of military pay should henceforth be included, now that the Indian Government is going into the business of public works on a large scale. It must construct them with a due regard to commercial principles, for even irrigation works and railways, like gold, may be bought too dearly.

The time has come not only for a reconstitution in principle of the public works organisation, but for a thorough investigation of the abuses in detail so often alleged as overweighting every operation of the department. The vague charges of corruption and excessive expenditure so frequently brought against it, but which seem to have more point on the other side of India than on this, are summed up and endorsed by a correspondent of the Allahabad paper, who writes as with the authority of long experience and close observation. He exonerates the Executive Engineers (nearly all R.E.'s) from all suspicion of profiting in the slightest degree by these abuses. But if the instances he adduces are to be accepted as typical, there has been a want of insight, and habitual neglect of close supervision and independent check, with a deficiency in knowledge of details quite sufficient to account for the abuses and serious malversations charged against the lower ranks of the department. These evils are remediable: but not without the exercise of firm determination and liberal encouragement of engineers and surveyors with practical knowledge of details, to which qualification must be added familiar acquaintance with the vernacular, long provincial experience, and settled contentedness with an Indian career. These conditions must be secured if the Indian Government is to go forward with its plans for the construction of larger works than ever. The correspondent already referred to, concludes his letter as follows:—

"After an experience of twenty-five years I can safely say—you may leave your army alone *if you wish.* You may arm your coolies, and dhobees, and tailors, if you will only look to your Department Public Works. But no State can afford to build permanent bridges and macadamise 100 miles of road for Brinjara (pack) bullocks and hackney wheels, or to build refrigerators in the shape of double-storied barracks—patent producers of asthma, lumbago, and rheumatism—costing lakhs of rupees, or to pour coin into the hands of native and European contractors, to simply carry out the departmental rule—of useless expenditure and wanton waste of money."

The break down of the Financial Secretariate, and the wrangle over the budget estimates, are not unimportant matters; but they are mere details compared with this question of the reorganisation of the Public Works Department, which demands the earnest attention of all the fast friends of India, whether here or at home.—*Times of India.*

TUNNELLING UNDER THE DETROIT RIVER.

There is to be a railroad tunnel under the Detroit river. An uninterrupted line of rails runs from New York to Chicago, with the one exception of the interval made by the river at Detroit. The transportation of freight by the ferry at this point causes great delay, and thus frequently blocks up the road so as to produce serious inconvenience. To obviate this, the Michigan Central and the Great Western Railroad of Canada have decided to tunnel the river. The project of a bridge was abandoned because a draw would have been necessary to allow the shipping to pass. Mr. Chesborough, the engineer of the Chicago tunnels, has examined the strata under the bed of the river, and reports that the formation is fit for the work. Although the river is only five-eighths of a mile wide, the whole length of the tunnel will be fully a mile and a quarter, in order to bring the roadway up to the grade. The depth varies from twelve to forty-two feet. Space for two railway tracks will be obtained by two distinct borings, eighteen feet in diameter, under the bed of the river, but they will be united in one when the banks are reached. The cost of the work is estimated at two and a half millions of dollars.

SOCIETY OF ENGINEERS.

ENGLISH AND CONTINENTAL INTERCOMMUNICATION.

By Mr. Perry F. Nursey.

One of the most prominent and important questions of the present day, and one to which a very wide-spread attention is being given, is that of providing a more easy and rapid system of intercommunication between England and France than we at present possess. Nothing is more obvious than the necessity which exists for improvements in this direction. The steam packet service between England and France—which is in fact a service between Great Britain on the one hand and Europe and the East generally on the other—is about the worst we have. It is an undoubted fact that the great majority of passengers crossing the Channel suffer—short as is the sea passage—extreme discomfort from sea-sickness and want of shelter during bad weather. Not unfrequently the traveller from India or from America finds the British Channel the most unpleasant part of his journey, and he sometimes looks forward with more anxiety to the state of the Channel than to the heat of the Red Sea or the passage of the Atlantic. In the case of America, he will often select a French or an English vessel, according to the country which he desires to reach, in order to avoid the Channel crossing, rather than from any other consideration. There are now, exclusive of the routes by Ostend and Antwerp, 310,000 passengers per annum to be provided for, of whom 142,000 travel by Calais, as the mail route. These numbers are undoubtedly capable of great augmentation on greater facilities and increased comfort being afforded. But the existing steam vessels, restricted as to their dimensions for want of better pier and harbour accommodation, are disproportionate to the service. Larger vessels, with less movement in rough weather, more shelter, and better accommodation generally, would do much to mitigate the discomforts of the sea passage. Pending the successful issue of other more extensive and more permanent projects, it would be well if these improvements were effected. But larger vessels cannot be employed for a fixed service until better provision is made for embarking and disembarking passengers, especially on the French coast. The Society of Arts, ever on the alert to improve the social condition of mankind, has offered its gold medal for the best design for a steamer which shall afford the most convenient shelter and accommodation to passengers on the deck of the vessel crossing between France and England. The attendant circumstances of the case, however, oblige the society to specify that the steamer is not to exceed in tonnage and draught the best vessels now in use between Folkestone and Boulogne. There have also been other schemes propounded at various times for vessels of special build suited to the present harbour accommodation. Into these propositions, however, it is not our present purpose to enter. The growing necessity for a radical improvement teaches us that they can only be regarded as temporary expedients which must give way in course of time to more permanent works. We will therefore proceed to the consideration of the more important and extensive projects which have been placed before the public during the last few years. These consist of tunnels driven beneath the bed of the sea, submerged roadways and tubes, large ferryboats carrying the trains on board, bridges across the Channel, and embankments.

If we glance at the history of the question we shall find it to extend further back into the past than is generally supposed. Something like a score of projects for effecting direct communication between the two countries have been proposed from first to last. Up to the close of the year 1866 three French projectors had proposed tunnelling under the Channel, five English and two French inventors had proposed submerged tubes, one Frenchman proposed an arched roadway or tunnel, and an Englishman a bridge. Since that time there have been some seven or eight proposals for effecting that object; to these attention will presently be specially directed. The idea of tunnelling is much the oldest; a French engineer, M. Mathieu, nearly seventy years since, considered the scheme practicable. He worked out the details of his plan and laid them before Napoleon, then First Consul. In 1856 M. Thomé de Gamond proposed a tunnel scheme which received more than ordinary notice. The plan was to form in the Channel thirteen islands by carrying materials out to sea, to sink shafts through them into the earth below the bed of the Channel, and then tunnel from one to the other. A commission of engineers was appointed, and they carefully examined M. de Gamond's data and conclusions, and particularly his geological investigations, which were the first steps taken to demonstrate practically the nature of the strata beneath the Channel. These investigations supported the theory that the Straits of Dover were not opened by a sudden disruption of the earth at that point, but had been produced naturally and slowly by the gradual washing away of the upper chalk; that the geological formations beneath the Straits remained in the original order of their deposit, and were identical with the formations of the two shores, being, in fact, the continuation of those formations. Acknowledging the scientific accuracy of M. de Gamond's conclusions, the commission recommended an appropriation of £20,000 to make preliminary examinations. The plan, however, was finally rejected on account of its interference with the navigation of the Straits. The submerged tube projectors of that time, with one or two exceptions, appear to have given the subject less study than the advocates of the tunnel. It was a work very easily effected: you only have to construct your tube in sections, float them over the proposed line of route, sink them and connect their ends, pump the water out, and the thing is done. Hear how one of these facile gentlemen describes his project:—

"My plan is simply to construct wrought iron tunnels in separate divisions, to sink them on the bed of the water, and then to connect them. It will be admitted that to construct such a tunnel would be an easier matter than to build iron vessels, as it would be the same shape the whole length. Then to sink it on the bed of the water would be the work of a few hours for each division of 400ft. in length." A momentary fit of reflection, however, seizes him when he has sunk his length of tube, for he says:—"Perhaps the part of the work which will appear the most complicated will be to connect the divisions under water." But, quickly recovering himself, he adds:—"The operation will be attended with no difficulty to those who can remain during half an hour under deep water." Turning to the shore end, he observes:—"As regards that part of the tunnel which would be near the shore, it would be sunk under ground, and covered with stones fastened together, so as to render them immovable.........Then the railway will be formed in forming the tube; there will be no hills to cut through, valleys to fill up, nor arches to build—in short, the sum total of the work is comprised in the tunnel itself." Warming with his subject, he grows bolder, and says:—"Supposing the divisions to be 1,000ft. in length; in that case, only 104 divisions would be required to join the rails of the South Eastern Railway with those of the Calais and Paris. Now, supposing each of these divisions would cost £40,000 the cost of the whole would be £4,160,000; and if we allow for the expense of throwing them in deep water, of connecting them, of building stations, &c., on a magnificent scale, it will, I believe, be found that the sum of £8,000,000 sterling would be quite sufficient to complete the submarine railway." Really the manner in which this gentleman speaks of throwing into deep water iron tubes a thousand feet in length, and capable of containing a railway, is most refreshing, and must have been very encouraging to the sea-sick continental traveller.

Turning to another project, we find it to consist in crossing the English Channel by means of a tube made of strong plate iron or cast iron, lined and prepared for that purpose, and which, placed at the bottom of the sea, should contain the two lines for the trains which would run within it. The slope given to the submarine railway would admit of a motion sufficiently powerful to enable the carriages to cross the Channel without a steam engine. The greatest depth of the sea at the middle of the Channel will admit of the construction of inclined planes, by means of which the trains would be enabled to reach a point where a stationary engine, or atmospheric pressure, might be employed in propelling the train to the level of the land railways of France and England.

Another visionary does not place his tube on the bottom, but proposes to situate it at a uniform depth from the surface, by means of ties below (and buoys above, if necessary), at suitable intervals. He says:—"The continuation of the tunnel on either shore I should dispense with; and, in order that it should have a partial freedom of motion, it should terminate with solid ends before reaching the shores. To these points chain piers should extend, or, if strict economy were aimed at in this item, the communication might be by small steamers." As the tunnel or tube in question contains only a single line, the projector proposes pushing one way and pulling the other, or he says electricity should, if at all practicable, be the motive power. After proposing, as the principle of construction, something analagous to the cooper's craft, he continues:—"When the tube was completed from end to end favourable weather should be waited for, and the work of lowering would then be accomplished nearly as follows:—The air-tight interior of each pontoon would be connected by an ample length of flexible pipe to an air pump of adequate power, on board a vessel anchored at a distance corresponding to that intended for the mooring weights. The two lines of vessels should be manned by steady men, each crew under a trustworthy leader. Athwart the vessels would be be laid from the shore the wires of an electric telegraph, communicating with an apparatus on board of each, so that at a preconcerted signal the abstraction of the air from the pontoons should be commenced simultaneously at a given time and carried on at a given rate. By this means the pontoons, gradually deprived of their buoyancy, would yield to the pressure of their burden, the buoyancy acquired by which as it entered its future element would be overcome by the weights with which throughout its length it was loaded, and which would speedily sink it to its prescribed depth. It would be when the tube reached the water that the mooring weights, having been preparatorily slung under the vessels above mentioned, would, at another signal by the electric telegraph, be simultaneously let drop into the sea, and drag down their charge along with them.

We will only briefly notice two more of these easy-going gentlemen whose ideas slip out so glibly that practical men fail to grasp them, and these are the proposer of the arched roadway or tunnel on the bottom and the proposer of the bridge. The former with 40 subaqueous boats of which he was the inventor, 1,500 sailors and navvies, 4,340,000 cubic yards of material, and £10,000,000, undertook to construct a tunnel by means of which the Straits could be crossed in thirty-three minutes. The mammoth bridge projector would make in the Channel 190 pedestals, 300ft. square at the bottom, consisting of rocks bolted and lashed together, gradually rising at an angle of 75 deg., till they formed each an insular plain, 150ft. square, 40ft. above the level of the sea. On these he would build towers 100ft. diameter, 260ft. high, crowning the whole with a tubular bridge 50ft. deep and 30ft. high.

Chalmers.

We will now turn to the more practical projects which have since been advanced, noting them somewhat in the order of their appearance before the public. First, then, comes the proposition for a Channel railway by the late Mr. James Chalmers, whose name is connected with some very valuable improvements in the construction of armour-plated ships and forts, but which his premature death prevented him perfectly developing. Mr. Chalmers' plan was to have a tube of boiler-plate iron, lined with brickwork, laid on the bed of the sea, and having ventilating towers at intervals.

Through this tube the railway was to be carried. His project provided for an unbroken double line, connecting the railways of England and France by easy gradients, capable of carrying all ordinary trains at the usual speeds on the best roads, and of insuring perfect safety and comfort. It was to offer no obstruction to the navigation of the channel, and Mr. Chalmers estimated that the work could be completed in three years for

£12,000,000. The principal features of the work, as proposed in 1866, were two strong iron tubes, cased with timber and lined with brick, each containing a single line of railway, and reaching from shore to shore on the bottom of the channel. The displacement and weight of these tubes was designed to be so nearly balanced that both in submerging and when in position they would not be subjected to any appreciable lateral strain. There would be a slight excess of displacement, which would be effectually overcome by the materials with which the tubes were to be covered. Mr. Chalmers held that as the current alternated up and down channel with the rise and fall of the tide the embankment would silt up eventually, and become a solid, impermeable mass, having the appearance of a ridge reaching from shore to shore, about 150ft. wide at the base, 40ft. high, and from 40ft. to 120ft. below the level of low water. Mr. Chalmers proposed to have the ventilators, one in mid-channel, and one about a mile from either shore. Thus the main portion of the work would be eighteen miles in length; and this, divided by the deep-sea ventilator, would give two sections of nine miles each. Consequently, a train could never be more than four and a-half miles from an opening. From those and other points the air was to be withdrawn through pipes by machinery situated in the central ventilator or on the shore embankments, which would cause currents of fresh air to rush to those parts most distant from the ventilators.

The tubes were to be circular in form, and made of boiler plate, double riveted and caulked. The circular form was to be preserved and the tubes were to be strengthened by iron girder frames surrounding them. To the outer flanges of these frames the timber casing would be attached by bolts, and the spaces between the timber casing and the tube proper filled with concrete. Finally, the interior would be lined with the most durable description of brickwork.

The timber casing properly caulked, says Mr. Chalmers, would be equal in strength and water-tightness to the planking of a frigate; the tube itself would be as tight and stronger than a steam boiler or iron ship, and the concrete packing between the plating and the tube would also be impermeable to water. Thus not only is a double or treble precaution taken against leakage, but the iron would be protected both without and within from any injurious effects that might result from contact with sea water; though, at the depth at which these tubes would be placed, such contact, even if possible, under the circumstances, would not be so injurious as if they were nearer the surface. Maury, in his "Physical Geography of the Ocean," states as follows:—"Count Marsigli divides sea water into surface and deep sea water; because when he makes salt from surface water (not more than 6in. below the upper strata) this salt will give a red colour to blue paper; whereas the salt from deep sea water will not alter the colours at all. The blue paper can only change its colour by the action of an acid. The reason why this acid (iodine?) is found in surface and not in deep sea water is that it is derived from the air." Hence, argues Mr. Chalmers, the bottoms of iron ships—when the interior skin of the iron is kept clean and well painted—appear to suffer little or nothing from the action of the water on the exterior. But, even if the iron of the tube were to suffer by oxidation in forty or fifty years (a circumstance which, from its position, Mr. Chalmers considers is far from probable), the embankment by this time silted up into a solid mass, the timber casing, the concrete, and interior lining would of themselves insure the permanency of the channel railway.

The ventilator in mid-channel was to be a circular mass of iron and stone, 100ft. in diameter, and 210ft. in height, 168ft. of which would be below the water-line. When finished it was to weigh about 100,000 tons, and displace 50,000 tons of water. It was to be surrounded by, and imbedded in, the embankment that covered the tubes, which at that point was to be raised to a height of about 80ft. The ventilators were to be ordinary air-shafts near the end of the shore embankments, which would be run out, breakwater fashion, about a mile from either shore to a depth sufficient for navigation over the tubes. The tubes were to be made in lengths of 300ft. or 400ft., were to be fitted with temporary bulkheads, lowered into position, and united by a somewhat delicate submarine operation

Hawkshaw.

Mr. Hawkshaw's attention has been directed to the subject of a tunnel for connecting the railway systems of England and France, and he has made a practical geological examination of the channel and the two coasts, the results of which are of great value in connection with the question. As Mr. Hawkshaw's scheme appears to have absorbed those of M. de Gamond and Mr. Low, an English mining engineer, it will be as well to trace the history of the combination concurrently with the development of the scheme. The project has been worked out under the auspices of a committee by Messrs. John Hawkshaw, James Brunlees, and William Low, English engineers, in conjunction with MM. Paulin Talabot, Michael Chevalier, and Thomé de Gamond. These gentlemen have reported to the committee of promoters of the undertaking, and that documents supplies the following facts and valuable information, from which we gather the history of the scheme.

Following the order of the report, we will first take Mr. Low's proposition. That gentleman has for several years past conceived the idea of connecting the railway systems of France and England by tunnelling, and as a practical mining engineer he has devoted his attention in the first place to securing the efficient ventilation of the work both during construction and after completion. In most of the tunnel schemes it is proposed to effect ventilation by means of towers in the sea more or less numerous, and differing in magnitude and cost. Mr. Low proposes to dispense entirely with shafts in the sea, and to commence the work by sinking pits on each shore, driving thence, in the first place, two parallel driftways or galleries from each country, connected at intervals by transverse driftways. By this means the air could be made to circulate as in ordinary coal mines, and the ventilation be kept perfect at the face of the workings. Another advantage attending this mode of proceeding is that these headings could be driven from shore to shore at the minimum of cost, and the practicability of executing the proposed tunnels demonstrated without extravagant outlay. The driftways were to be turned into two tunnels suitable for the ordinary locomotive traffic of the railways to be connected by this work. Having settled the principle of the construction of his tunnels, Mr. Low investigated the geological nature of the shores of the Straits. From personal examination of the most careful character, he verified the data of Mr. Phillips and of other eminent geologists who have made the geology of the shores of the Straits, and the subject of the continuity of the strata under the sea, their special study. He also examined the borings for the artesian well at Calais, the artesian well at Harwich, and several other wells of less magnitude, by all which the regularity of the strata was proved. He found everywhere that the deductions of the geologists were sound; and at the line which he ultimately fixed on for his proposed tunnels, viz., about half a mile west of the high light of the South Foreland, and at four miles west of Calais, the tunnels could be made almost entirely through the lower or grey chalk, which, owing to its comparative freedom from water, and the general absence of cracks and fissures in it, offered the most desirable stratum for working in. Mr. Low laid his plans before the Emperor of the French in April, 1867, and his Majesty desired Mr. Low to proceed to organise the means of carrying out his project, and to come to his Majesty again when he was prepared to lay definite proposals before him.

In an international work of this nature it was desirable to obtain the co-operation of a French engineer, and Mr. Low therefore put himself in communication with M. de Gamond, who placed his geological studies and sections at Mr. Low's disposal. Mr. Low then laid the results of his and M. de Gamond's labours before Mr. Brunlees, who, after a careful examination of the project, consented to co-operate with Mr. Low and Mr. Thomé de Gamond for the prosecution of the proposed work. In accordance with the desire of his Majesty a committee of French and English gentlemen was formed in furtherance of the project.

For some years past Mr. Hawkshaw's attention had been directed to this subject, and ultimately he was led to test the question, and to ascertain by elaborate investigations whether a submarine tunnel to unite the railways of Great Britain to those of France and the continent of Europe was practicable. With this object he caused to be made a careful examination of the geology of the channel and of the French and English coasts, and had a chart prepared, based on that examination, and on such further information as he could procure. From a careful consideration of these geological investigations, Mr. Hawkshaw arrived at the conclusion that it was desirable that the tunnel should pass as far as possible through the lower chalk, for it appeared to him that if an attempt were made to carry it through the strata lying under the chalk it would have to penetrate material of variable nature, some of which would be soft, and through which it would be undesirable to construct a submarine tunnel. It also seemed to him desirable to depress the tunnel as much as possible below the upper or white chalk, and to carry it as far as practicable through the lower or grey chalk, which is less permeable to water than the upper or white chalk. But when he had proceeded thus far Mr. Hawkshaw felt that more accurate information than could be arrived at by geological inquiries only, however carefully conducted, was necessary. He had ascertained that at Calais an artesian well had been sunk to a depth of about 1000ft., and from the records of this work he obtained the particulars of the strata at that point. This well which failed to procure water was some distance from the spot on the French coast, where, from the geological inquiries, it seemed desirable that the submarine tunnel should be placed. He therefore decided to make borings on each coast at the ends of the line which approximately seemed the best position for the tunnel, and also to examine the bottom of the channel for some distance on each side of that line. Accordingly, at the beginning of the year 1866 a boring was commenced at St. Margaret's Bay, near the South Foreland; and in March, 1866, another boring was commenced on the French coast, at a point about three miles westward of Calais; and simultaneously with these borings an examination was carried on of that portion of the bottom of the channel lying between the chalk cliffs on each shore.

The boring on the English coast was satisfactorily completed in 1867. It was carried through the chalk and into the green sand, which was reached at a depth of 540ft. below high water. The boring on the French coast was continued from the surface to a point about 520ft. below high water. It passed through the upper chalk into the lower or grey chalk. This was completed at the end of 1867. It was Mr. Hawkshaw's intention to have carried this boring also entirely through the chalk, but in attempting to substitute larger boring tubes the hole was accidently filled up with sand and shingle from the top. The results, however, arrived at from this boring seem sufficient, and accorded very nearly with the records of the Calais well, and with the geological survey previously made; so as not only to confirm their accuracy, but to lead to the deduction that at the site of this boring the chalk would extend to, and the green sand be reached at a depth of about 750ft. below high water.

For the examination of the bottom of the channel a steamer was engaged and suitable apparatus provided by means of which the bottom could be pierced for a short distance and specimens could be raised from the bed of the channel. On shore suitable points can be selected for examining the strata; whilst at sea many of the examinations made from soundings fall on superficial deposit. A survey of the channel therefore cannot be so complete as a survey of the coasts. Nevertheless, the result of the examination seems to indicate that across the channel the position of the chalk is nearly identical with that deduced from the previous geological inquiries.

The principal practical and useful results that the borings have determined are that on the proposed line of the tunnel the depth of the chalk on the English coast is 470ft. below high water, consisting of 175ft. of upper or white chalk and 295ft. of lower or grey chalk; and that on the French coast the depth of the chalk if 750ft. below high water, consisting of 270ft. of upper or white chalk and 480ft. of lower or grey chalk; and that the position of the chalk on the bed of the Channel ascertained from the examination nearly corresponds with that which the geological inquiry elicited. It also appears probable that there is no great fault or serious interruption in the continuity or regularity of the strata between the two shores on the proposed line of tunnel. The results of these investigations were submitted to M. Michel Chevalier and M. Paulin Talabot, and they were put in possession of all the information that had been obtained.

Such, then, is the history of the separate investigations which have been made into this important and interesting subject, and the general nature and result of those investigations. We will now proceed to the conclusions at which the members of the Committee of Engineers arrived after consulting together and comparing the several data.

They submit that it is evident that at some sufficient depth below the bottom of the Channel a tunnel could be constructed, so that, as regards superincumbent pressure only, it would be analagous to constructing a tunnel of similar length through a mountain so high as to prohibit intermediate shafts; it is further evident that any possible irruption of sea-water may be avoided by going deep enough below the bottom of the Channel. On the other hand, they observe that there is a limit to the depth at which the tunnel can be carried, from the necessity of approaching it from the shore and obtaining gradients for those approaches suitable for railway traffic. If the tunnel were carried through the upper or white chalk, or chalk with flints, apart from a possible irruption or percolation of water from the sea, fresh water might be encountered to the usual extent that it is met with in that formation. But the tunnel can be depressed so as to pass mainly through the lower or grey chalk, which is less permeable, and where the quantity of fresh water would be comparatively unimportant, provided no great fault or dislocation of the strata exists—and the investigations lead to the conclusion that no such fault does exist—it is probable that at the depth below the bed of the Channel at which it would alone be prudent to carry the tunnel, any fissures that may occur in the chalk have been filled up, and that from this circumstance, and from the nature of the lower chalk, no more water will be met with than can be overcome by pumping.

With regard to the execution of the work itself, the committee of engineers consider it proper to drive preliminary driftways or headings under the Channel, the ventilation of which would be accomplished by some of the usual modes adopted in the best coal mines. All other questions in relation to the construction of the permanent tunnels would be decided from the experience gained in making the driftways, and it might even be deemed advisable to commence the formation of the permanent tunnels before the completion of the driftways, if circumstances indicated the desirability of that course. They propose that the tunnel should be of the ordinary form, sufficiently large for two lines of railway, and to admit of being worked by locomotive engines, and artificial ventilation could be applied. The desirability of adopting other modes of traction is left for future consideration.

Finally, the following general conclusions are submitted:—1. That there is a reasonable prospect that the work can be accomplished, but that it would be improper to deny that it is attended with a considerable amount of risk. 2. That this risk is attended with one contingency, viz., the possibility of sea water finding its way by some unforeseen fissure into the workings in quantity too great to be overcome; apart from this risk, tunnelling in chalk is easy and rapid, and the execution of a tunnel of the length of the one under consideration is only a question of time and expense. 3. There seems to be no reason to assume that the tunnel would cost more than ten millions sterling, or that it could not be completed in nine or ten years. 4. The question of risk would be fully solved by sinking land shafts on either coast, and driving the preliminary driftways; this portion of the work being safely accomplished, the remainder would be of an ordinary character. 5. The possible cost would be measured by the cost of this preliminary work, which is estimated at one million and a half, and which could not exceed two millions, or, say, one-fifth of the whole cost of the tunnel. 6. That this risk should be undertaken by the Government of France and England, if, after consideration, they deem the importance of the work and the probability of its completion sufficient to justify them in doing so.

Austin.

Towards the close of last year Mr. W. Austin proposed a sub-marine three-way tunnel under the Channel. His plan is to cross at a line of route extending from the landing piers at Folkestone to the landing piers at Cape Grisnez, but the tunnels will range below the sea level, at a safe depth for practical permanent masonry arches, which will be constructed of imperishable materials on an improved principle of vertibraical bond. The tunnel is intended to pass underneath the submerged island called the Varne lying near the mid-channel, and on which island Mr. Austin proposes to erect a central ventilating shaft or tower, which would be available as a permanent central lighthouse and naval signal shaft; also to afford a refuge or retreat for crews of ships wrecked in the Channel. As a fence or guard to this central tower or shaft, it is proposed to have two ranges of timber floating breakwaters, so as to act as floating retreats for ships, and protectors to the tower shaft from hurricanes or gales. Two other masonry shafts will be permanently constructed for ventilation and pumping purposes at each shore. Seven or eight temporary shafts will also be constructed in iron, and sunk and bored down to the tunnel arching, so as to give ventilation to workers in the construction of the tunnels, and also to receive a portion of the excavated debris. Those temporary shafts would be protected by moored floating booms or fences during the construction of the tunnel, and on the completion of the tunnel, the temporary shafts and booms would all be removed, having done their work. The gradients of inclines of the proposed tunnels would be so arranged that the steepest gradients of the two shore inclines, or connections with the main land railways in England and France, do not exceed 1 in 100, so that locomotives of moderate powers would accomplish the required work easily.

Occasional openings are to be constructed in the masonry range of tunnel wall sides, so as to allow for a traverse of engines and carriages from one range of tunnel to another in the event of any accident or emergency, when traverse frames would quickly shift the disabled carriages out of the way of an obstructed traffic.

Arrangements of a distinct and peculiar character were to be made for the proper ventilation of the tunnels, by air and water streams; also for the lighting the tunnels throughout by perfected modes of gas burning in specially constructed lamps, &c. Every facility will be provided for laying down a perfect system of telegraph conducting wires, which will be easily accessible for adjustment and repair; and the present great risks of accidents, now so often recurring, of tearing up cables by ships' anchors will then be avoided. Subways are to be constructed throughout the tunnel ranges which will exhaust any accumulation of steam or waste waters or temporary leakages, and which water will be passed through well-pits, and then ejected by pumps, connected with the great central shaft and two shore shafts. The advantages of three tunnel ranges will be to keep special, ordinary, and goods traffic trains separate and distinct, and thus obviate present causes of frequent accidents by clashing trains conveying passengers and goods on the same ranges.

Fowler.

Mr. John Fowler has for several years past directed his attention to the best mode of improving continental communication, and he prefers a system of ferrying the trains over in steam vessels rather than either a bridge or a tunnel. He has had for the last two years associated with him Mr. Abernethy, and Mr. Wilson as acting engineer. After a careful examination of the harbours of Calais and Boulogne and the coast between them, and after considering the general question, these gentlemen came to the conclusion that the following were essential requirements:—

1. Well-sheltered harbours with deep water on both coasts, capable of affording ingress and egress at all times, irrespective of weather and tide.

2. A class of vessels, in the nature of ferry steamers, of great size and power, making rapid passages, and comparatively unaffected by wind and sea. 3. Safe and speedy means for the interchange of passenger traffic between the railways and such ferry steamers, so as practically to form a continuous communication. Conceiving that the harbour and pier at Dover afforded very inadequate terminal accommodation and insufficient protection, particularly from easterly and south-easterly gales, they propose the erection of a new harbour westward of the existing pier, with a graving dock, a covered berth for the steamers, and hydraulic apparatus for transferring the trains from the quay to the steamers, and *vice versâ*. They consider that Calais, which was exposed to all winds from west to east, and was choked up with sand, offers no facility for a harbour for such steamers; and that the harbour of Boulogne, though more readily capable of partial improvement, partakes of the same natural defects of sand accumulation. They have, therefore, selected a point of the coast south of Cape Grisnez and north of Ambleteuse, near the village of Audresselles, where the deepest water was to be found near the coast, and sheltered from the northward and the eastward by Cape Grisnez. They consider that by constructing a harbour at this point they will secure the shortest available sea passage, with clear navigation across the Channel from Dover, and with the advantage of the first-class light on Cape Grisnez as a guide on the darkest nights. They propose to connect this harbour by a railway four miles long with the Chemin de Fer du Nord, and to add a short branch for communication with Calais and the north. The steam vessels the projectors of this scheme propose to employ between these harbours are to be 450ft. long, with 57ft. of beam, and 80ft. across the paddle-boxes, propelled by disconnected engines of 1,500 horse-power, performing the voyage in one hour, and with comparatively little pitching or rolling in any state of the weather. They further propose to form covered stations for the interchange of passenger and goods traffic between the steamers and the shore, the transfer of the passenger carriages to be effected by hydraulic apparatus, irrespective of tide, in a few minutes. The steamers are to be luxuriously fitted up with first and second class refreshment saloons, and with ladies' and private cabins; and in addition to the saving of time in the sea passage and on either coast the passengers are to have the advantage of being able to secure and retain the seats in their railway carriages throughout the journey between London and Paris and other centres. At the same time the various saloons and cabins and the decks of the steamers will be at their service. The projectors believe that the extra comfort to the passengers afforded by such accommodation, and by the regularity of the service, is far more important than the saving of time that would be effected. They reject as insufficient and unsuited to the requirements of the present day all partial improvements of Boulogne Harbour and the service between that harbour and Dover or Folkestone; and they estimate that these works and the railway steam ferry steamers may be completed within three years, at an expenditure of £2,000,000.

Remington.

In 1865 Mr. George Remington published a plan for the construction of a tunnel railway from Dungeness to Cape Grisnez. Before advancing his scheme Mr. Remington ascertained, as far as possible, the nature of the geological strata forming the bed of the Channel. He found that the coast in the neighbourhood of Dover and Folkestone consisted of chalk, which extends under the Channel to the Calais shore. As Mr. Remington concluded that this formation, which is in itself so very porous and contains so many fissures, could not be suited for tunnelling under a great head of water, he visited Dungeness, and examined the whole line of shore from Hastings to Dover, and satisfied himself that the Wealden formation, consisting of very strong clay beds of freestone, and fresh water limestone, extended from Dungeness across the Channel to Cape Grisnez. Having concluded that that was the proper course for the construction of the tunnel, he at once proceeded to prepare plans and sections, and laid them before the Board of Trade, the Minister of Works, Paris, and others. This proposition has again been brought before the public within the last few months.

The line is intended to commence at the town of Lydd, where it will join the branch railway from the South-Eastern at Appledore. It will descend from Lydd at an inclination 1 in 70, the distance of three and a half miles, to the point of Dungeness, where the level of the rails will be 210ft. below the level of low water spring tides. The rails would then rise from Dungeness shaft at the rate of 1 in 3,795 for about 7 miles, and then fall at the rate of 1 in 1,200 for about 8 miles, to the centre shaft on the "Ridge;" from thence fall at the rate of 1 in 3,265 for 11 miles to the Cape of Grisnez, and then rise at the rate of 1 in 70 and 1 in 81 to join the French railways.

The height of the tunnel will be 30ft. from the soffit of the arch to the centre of the invert, and there will be a clear headway of 20ft. for the trains: the space between the rails and the invert will be occupied by a sewer, running along the centre line of the tunnel, and on each side of it two air tunnels for the purpose of providing ventilation. The width of the tunnel will be 25ft.; it will be constructed of brickwork and masonry, surrounded with concrete, and also a mass of concrete will be placed upon the invert surrounding the air and drainage tunnels, and forming a bedding for the sleepers of the railway.

There will be three main shafts of large dimensions. The centre shaft on the "Ridge" will be protected by a breakwater, formed of rubble and faced with ashlar. The other shafts are to be effected by means of wrought iron tubular piles from 8ft. to 10ft. in diameter, the inside strengthened with plates on the cellular principle. These piles will be provided with valves to regulate the ingress and egress of water during the time of sinking into position, and when sunk they will be supported by proper guy chains and tackle from anchor moorings placed in various directions around the piles, every pile forming a shaft of sufficient length to reach the entire depth of the water and through the bed of the Channel down to the level of the tunnel. It is intended to weight the lower end of the piles, and to sink them into position on the principle of the angler's float. The water will then be pumped out by steam power, and the soil be brought up from the interior and cast over on the outside, forming a cone round the pile. Mr. Remington estimates the cost of these works at £6,998,200.

Marsden.

Mr. Charles Marsden's scheme, which was brought before public notice in April last, consists of a tubular tunnel, made of boiler plate, and having a double skin, on the well-known principle used in shipbuilding, the annular space being filled in with artificial stone. Mr. Marsden purposes to carry pipes for ventilating the tunnel, as well as pipes for water, sewage, and telegraph wires, at the top of the tunnel. At the bottom runs the line of road, on which the railway is laid. The ventilating pipes are formed with longitudinal slots. Air is to be forced from the short ends into these tubes, which will pass through the slots, into the tunnel, and ventilate it. Mr. Marsden has a special plan for joining the several lengths of the tube. It consists in fitting one end of the tube with a series of stepped or curved plates, which are secured in place by screws or rivets. The adjoining end of the next pipe is fitted with a bulge or socket. Another series of plates is employed, one end of which is forced upon the open end of the stepped plates. They are prevented from falling out by being guided into position by a number of rings, fitted on the end of a pipe. Another ring is employed on the outside, to hold the plates. A portion of this ring is looped or pocketed, to enable the plates to be placed in position. When passed through this looped portion, they are made to slide round in succession, so as to meet each other, until the whole diameter of pipe end is covered. They are then firmly secured in place by keys being driven in between them and the ring. The loop is then filled in with a wedge-piece, and thus the whole joint is made sound, flexible, and tight. The joint being flexible admits of its adapting itself to the general contour of the bed of the Channel, and follow any undulation caused by a settlement of the soil.

It is proposed to lay this tunnel in the following manner:—A cutting is first to be made on land about two or three miles in length, gradually descending to a point where the water is about ten fathoms deep. A sea wall is to be built about 50ft. from the water's edge. A portion of a cylinder is to be built in the wall and made water-tight, and the sea is then to be allowed to flow up to the wall, so that the next cylinder can be floated and placed in a proper line. The same with the next, and so on, lowering them from a raft which they will form. Mr. Marsden proposes that divers should cut through moderately high projections in the Channel bed, and also the levels, making a trough, into which would be lowered clay, the divers puddling the same, and thus forming a bed for tubes to rest upon. The cylinders can be made on the coast, and, when finished, have their ends stopped and be towed to the spot required, half filled with artificial stone composition. Four or six of the tubes can be used to form a raft or stage to carry the machinery for lowering or fixing the tube in place, and afterwards can be used on the land and to finish the connection on shore. By this means Mr. Marsden estimates a working tunnel could be completed in about four years, without the danger of its being flooded. The heading at each end is to be made in three or more parts, and well secured with india-rubber, or other packing, and screw bolts. The heading, after two or three of the cylinders are fixed together from the outside, is to be removed from the inside, making an entrance from the shore end into the next tube, and so on throughout. The double cylinder is braced to keep the inner from the outer. The space between the two, which is 5ft. or 6ft., is to be filled with tarred granite and asphalte, which will form a perfect wall. As Mr. Marsden considers it impossible to have a ventilating shaft in the Channel, he proposes to have machinery on each shore to abstract the vapours from, and also to force air into, the tunnel. Mr. Marsden's estimate for a tunnel between England and France on his principle is £12,260,000.

(To be continued.)

ROYAL GEOGRAPHICAL SOCIETY.

The second meeting of the present session of this society was held on Monday, November 22, Sir R. I. Murchison, Bart., President, in the chair. Before proceeding to the ordinary business, the President addressed the meeting on the subject of the Faraday Memorial. He said that when the world of science was deprived of that illustrious man, Michael Faraday, he was honoured by being named one of those Presidents of societies who were appointed to organise the public meeting which was presided over by his Royal Highness the Prince of Wales, and at which it was resolved to erect a statue in memory of the great philosopher in the Cathedral Church of St. Paul. On that occasion the feeling in favour of this resolution was strong and unanimous, and the object was most eloquently sustained by the eminent French chemist Dumas, one of the Perpetual Secretaries of the Institute of France. He regretted to say, however, that at this moment the subscription fund must be considerably increased, to enable them to pay for a suitable monument in marble by an eminent sculptor. As one who learnt his first lessons in science under Faraday, and who, in every succeeding year, admired more and more his great genius as well as the simplicity and benignity of his character, he (the President) called upon his associates of the Royal Geographical Society, and their friends who might not have subscribed, to do honour to themselves by supporting this good cause. In doing so, he begged them to recollect that it was in the theatre in which they were then assembled that Faraday delighted and instructed vast audiences for upwards of thirty years; and that in the same theatre, so adorned by him, geographers had now the privilege of holding their meetings, owing to the liberality of the President and managers of the Royal Institution. Subscriptions for the Faraday Memorial would be received by the Assistant Secretary of the Royal Geographical Society, and also by the Assistant Secretary of the Royal Institution.

The paper of the evening was "On the Exploration of the New Course of the Yellow River of China," by Mr. Ney Elias, F.R.G.S. The author stated that having planned a survey of the course the great Yellow River of China had taken since breaking through its old banks some fifteen years ago, he devoted his autumn holiday in 1868 to carrying out the object, having previously secured the approval of the Shanghai Chamber of Commerce. Only the vaguest accounts had previously been received of this grand phenomenon caused by the river forsaking its bed several hundred miles from its mouth, and pouring its waters in a northerly direction, seeking an outlet in the sea at a point separated by four degrees of latitude from its former mouth, leaving a dry bed two or three miles wide, which was now used as a high road. By the change scores of square miles of highly cultivated country had been devastated, numbers of people had lost their lives, and, along the forsaken bed, other districts were deprived of their fertility by the loss of the means of irrigation. No less than nine such changes were recorded in Chinese history, the first dating about 602 B.C., the positions of the various mouths ranging over the extent of coast between 34° and 39° N. lat. The author believed that the major part of the great alluvial plain of China had been formed by the rich deposits left by forsaken beds of this singular river. The author's companions were Mr. Hollingworth and two Chinese; they left Shanghai, well provided with instruments for taking observations in latitude and longitude, on the 24th of September, and after a journey of nearly 400 miles on the Grand Canal, arrived on the 17th of October on the banks of the new Yellow River near the town of Nan Chan. At this point the stream had not yet worn for itself a bed, but was spread over a belt of country some ten to twelve miles in width. The banks of the Grand Canal have here been carried away by the invading stream, and the whole country wore an air of desolation. The party embarked on the new river near here, and traced it down to its embouchure in the Gulf of Pe-chi-li. Nineteen miles downwards the wide-spread waters converge and flow into the narrow bed of a much smaller river, the Tatsing, which henceforward serves as its channel. The great volume and rapidity of the waters of the Yellow River are causing the narrow bed to widen, and with the undermined banks are swept away the streets of villages and cities, gardens and fields. Bridges, which formerly spanned the Tatsing, now remain as ruins in mid river; at Tsi-ho-hien one of the bridges effectually stops navigation, at present, at a short distance above the port of Tsi-nan-foo. Towards the sea the banks of the river are marshy and uninhabitable, the limit of the peopled region being the small port of Tu-men-quan. The mouth of the river is obstructed by a bar, which Mr. Elias found, on October 27th, to have a minimum depth at low water of 3½ to 4 feet. Deeper channels in the bar have from 5 to 7 or 8 feet of water. From various considerations the author concluded that the new course of this large river was not likely to be used by the larger trading junks, and that, in fact, its commercial value was very small. In returning to Shanghai by the river, the party ascended to the point where it first broke from its former course, near Lung-men-Kau. The date of the first breach was 1851, but the waters were not finally diverted till 1853. The paper was accompanied by a carefully executed chart of the new course of the river, constructed on an ordinary traverse survey, checked at several points by observations for latitude and longitude. Soundings were observed throughout.

In the discussion which followed, Capt. Sherard Osborn, R.N., bore testimony to the great geographical value of Mr. Elias's paper. The Yellow River had been generally spoken of as a rapid and dangerous stream, remarkable for the mass of alluvium it carries down, and with which it is continually silting up and raising its own bed. The great plain of China, which in 1813 supported 170,000,000 inhabitants, is in great measure formed of the alluvium brought down by this river from the western highlands; the rich soil having a depth, according to Davis, of 70 feet. Uncontrollable as the Yellow River appeared to be, it was waiting only the hand of the European engineer to put a bound to its turbulence, and guide its superabundant forces into channels useful to man.

Mr. Wylie, who had recently returned from extensive journeys through the interior of China, spoke of the great accuracy of Mr. Elias's descriptions. Mr. W. Lockhart and Mr. T. Sanders also took part in the discussion.

THE INSTITUTION OF CIVIL ENGINEERS.

THE ANNUAL GENERAL MEETING.

In reviewing the events of the past twelve months, completing the fifty-second year since the foundation of the institution, the council stated that the proceedings had furnished corroborative evidence of the sound basis on which the society was established—a basis which had been taken as the model for many analogous institutions, both at home and abroad.

Referring to the business at the ordinary general meetings, of which there were twenty-two during the past session, attention had been directed by the papers read, and by the discussions, upon them, to the use of machinery in lieu of gunpowder for "getting" coal; to cylinder foundations for bridges and other similar structures; to the midland line of the Mauritius railways, where exceptionally steep gradients and sharp curves were necessarily adopted; to some of the chief peculiarities of American locomotives and rolling stock; to works carried out in connection with the river Witham and estuary, for the drainage of the fens and the improvement of the navigation; to the past and present condition of the outfall of the river Humber, and of its peculiar feature, Spurn Point; to the New Ferry and the new Brighton piers and landing stages on the river Mersey; to the low water basin at Birkenhead, and the extensive sluicing operations for maintaining the basin at its proper depth; to the lagoons and marshes on certain parts of the shores of the Mediterranean; to the mechanical details of construction of lighthouse apparatus and lanterns; to the Roman Rock lighthouse, Cape of Good Hope; to the standards of comparison for testing the illuminating power of coal-gas; and lastly, to an able summary, by a foreign engineer, of the present state of knowledge as to the theory of the strength and resistance of materials of construction.

The originality, labour and ingenuity displayed in these communications, had led to the award of Telford medals and Telford premiums of books to Messrs. Jules Gaudard, W. Shelford, T. N. Kirkham, J. Ellacott and D. T. Ansted, F.R.S.; of a Watt medal and a Telford premium of books to Mr. Z. Colburn; of Telford premiums of books to Messrs. W. H. Wheeler, J. R. Mosse, I. Bell, J. Milroy, S. P. Bidder, jun., and C. J. Chubb; and of the Manby premium of books to Mr. D. M. Henderson.

In addition to the ordinary general meetings, there were six supplemental meetings, for the reading and discussion of papers by the students. In consequence of the students having failed to supply further papers, the council were not able to extend the number of these meetings. This they regretted, being persuaded that such meetings and the due preparations for them could not fail to be productive of the greatest possible advantage. For the papers read at these supplemental meetings, Miller prizes had been awarded to the following students: Messrs. E. Bazalgette, F. H. Mort, T. J. Ellis, T. R. Gainsford, C. H. G. Jenkinson, and G. H. Roberts.

It was stated that during the past year upwards of seven hundred volumes and pamphlets had been added, either by presentation or by purchase, to the library, which now contained about five thousand eight hundred volumes, and four thousand three hundred tracts, on every branch of civil engineering, and in many different languages. A portrait of Mr. Fowler (past-president), painted by Mr. J. E. Millais, R.A., had also been received, and from Mr. McClean, M.P. (past-president), seventy-two engraved copper plates, which had been used to illustrate an early edition of Smeaton's reports.

During the last session 30 members and 82 associates had been elected; but as the deceases, resignations, and erasures from the register were double what they had been in any previous year, the actual increase in the gross total of the several classes composing the corporation was only 42, or 2.7 per cent. on the present number. There were on the books on the 30th of November 148 Students, as against 133 at the same date last year. If the students were included in the enumeration, as the graduates used formerly to be, it would be found that the gross number of all classes now on the list was more than double what it was twelve years ago—1739 as against 857. The actual numbers of the four classes—honorary members, members, associates, and students—were 16, 655, 920, and 141 respectively.

The deceases announced since the last annual meeting had been nearly 16 in the thousand on the present number of members belonging to the corporation, and comprised Dr. Peter Mark Roget, honorary member; Messrs. John Clark, Thomas Duncan, John Godwin, John Henry Hartwright George Lowe, John Manby, John Mattbew, Henry O'Hagan, William Michael Peniston, John Shae Perring, Neil Robson, James Simpson, and William Græme Tomkins, members; and Messrs. Charles Billson, Charles Capper, Francis Gordon Davis, Liddle Elliot, John Hamilton, William Jerry Walker Heath, Charles Edwin Heinke, Edward Hooper, Nathaniel Nicholls, Thomas Edward O'Brien, and Thomas Hardy Taylor, associates. The list included the names of two very old members, one of whom, Mr. George Lowe, has been borne on the books since 1823, and had served for several years on the council; while the other, Mr. James Simpson (Past President), was elected in 1825, and was for a long period one of the most active and influential members of the council, during which time he took a leading part in the administration of the affairs of the Institution, especially in all matters of finance, and who so ably occupied the presidental chair in the years 1854 and 1855.

The ordinary receipts for the past year had amounted to £7,032, being only

£141 less than they were in 1868, notwithstanding the loss of dividends due to the sale of stock necessary to meet the expenses of the new building. The expenditure in the same period (exclusive of the new building), had been £3,786. During the financial year ending on the 30th of November last, a sum of £8,498 5s. 6d. was paid on account of the new building and its accessories, making, with the sum of £9,711 16s. 10d. expended up to the date of the previous annual meeting, a total outlay of £18,210 2s. 4d. This outlay had been entirely defrayed out of the funds of the institution, viz., £10,146 1s. 8d. by the realisation of investments, £2,209 16s. 2d. from the Locke Gift and Bequest (which had been received too recently to be invested), and the balance £5,754 4s. 6d., from the surplus income of the last two years. It should be mentioned that the building fund proper had only contributed £5,712 5s. 10d. towards this outlay. The remaining balance of £12,497 16s. 6d. had been obtained from the general funds,—an amount which the building fund fees on election would probably not be able to reimburse for the next quarter of a century. The nominal or par value of the several funds under the charge of the Institution, on the 30th of November last, was, I., General Funds, £7,656 1s. 8d. ; II., Trust Funds, £12,119 15s, 8d.; and III., Cash Balance, £268 9s. 9d., making a total of £20,044 7s. 4d., as against £29,835 18s. two years ago, when they were at a maximum. This showed a decrease in the interval of £9,798 10s. 11d.; but it was to be remembered, as previously stated, that in that period a sum of £18,210 2s. 4d. had been paid on account of the new building. The funded property of the Institution, irrespective of that held under trust, amounted at present to the very satisfactory sum of £7,656 1s. 8d. nominal value, producing an annual income of £292 16s., while the trust fund realised £398 11s. 10d. a year, in both cases without deducting income tax.

The council had recently taken vigorous measures to vindicate the honour of the profession, which had been unjustifiably assailed by the Government of India, in a notification the plain intention of which could only be, to charge civil engineers with recognising as legitimate the receipt of commissions from others than the immediate employers, and in addition to their salaries, where so remunerated. The Secretary of State for India had put on record "that he regards with implicit confidence the indignant repudiation by the Institution of the recognition of any such practice as that referred to," and that he would call upon the Governor-General in Council for an explanation of the circumstances which led to the issue of the objectionable notification. A sufficient time had not yet elapsed for an answer to be received from India to the remonstrance of the Institution. In the meantime the council felt assured that the steps they had taken would meet with cordial approval.

In inviting attention to this report, the presentation of which terminated the trust confided to them by the annual general meeting, the council observed that they had laboured so to direct the affairs entrusted to them, that the discharge of their duties might be attended with advantage to the Institution.

THE PUBLIC WORKS OF THE PROVINCE OF CANTERBURY, NEW ZEALAND.

By Mr. EDWARD DOBSON, Assoc. Inst. C.E.

In this communication a history was given of the Public Works Department of Canterbury, from its establishment, in 1854, to the completion of the railways, in 1868. During that period the survey of the province, commenced under the "Canterbury Association," had been completed by the officers of the Survey Department; the eastern portion of the province had been thrown open to settlement, by the construction of many hundred miles of metalled roads; the western goldfields had been connected with the capital, by a coach-road through the passes of the New Zealand Alps—a road remarkable both for the boldness of its design and the circumstances under which it was executed; and a complete system of railroad had been surveyed, the key to which (a tunnel 129 chains in length through the crater wall of Lyttelton Harbour) had, been successfully completed. Extensive harbour works had been constructed public buildings erected in the principal towns, and telegraph and postal services carried to a fair state of organisation. The total expenditure on public works and surveys during the period referred to had been, in round numbers, £1,800,000, out of a total Government expenditure of about £2,880,000. The whole of this outlay had been defrayed out of current revenue, with the exception of about £500,000, raised on debentures, secured upon the railways and upon the Land Fund. The population in 1854 was about 6,000; in 1868 it amounted to a little under 54,000, including the mining population of the county of Westland.

The great bulk of the public works of Canterbury possessed but little professional interest—the country being level, and the bridges chiefly of timber of ordinary construction. Many of the rivers run on ridges above the general surface of the plains, and in dealing with them it was essential to leave abundant waterway, as there was little chance of any ordinary embankment standing against such torrents as they sometimes carried. Paradoxical as it might appear, the portions of the proposed railways, which were to traverse the level plains would require heavy earthworks, on account of their running at right angles to the water courses, while the lines through the ranges, being contoured on the hill sides, would be carried for miles on surface gradients, with light side cutting, through a mountainous and difficult country. The fact that a mere handful of settlers, spread over a country nearly equal in area to the whole of Ireland (the province of Canterbury having a coast line 200 miles in length, with a breadth of 120 miles), had been able, out of provincial resources alone, to execute works to the extent of nearly two millions sterling, deserved attentive consideration, as exhibiting a degree of success not often recorded in the history of colonisation.

It was necessary at an early date to decide upon the main lines of communication, in order that isolated works executed without any apparent connection might ultimately (as the temporary circuitous tracks became closed up by fencing) form portions of a connected whole; and to accomplish this the Government had to incur an outlay which might appear unnecessary, but which in reality saved a heavier expenditure than would otherwise have been requisite. The difficulties which had to be contended against were then set forth, and it was stated that the greatest of all arose from the fact, that the works could only be put in hand by driblets, often at at long intervals, and to such an extent as might be warranted by the progress of the land-sales, and as might be authorized by the Provincial Council, whose views, as might be expected, were generally swayed by local wants and local interests. These difficulties were further intensified by the physical character of the country. The agricultural land was situated principally in the swampy tract on the seaboard; the pastoral on the higher portion of the plains and in the back ranges. The farmers, therefore, wanted the money to be spent in bridging creeks and in metalling the swampy roads near the coast. The sheep-owners desirded side cuttings to be made in the hills, and approaches to the fords in the gullies, in order to get their wool-drays to their stations. The farmers took their grain to market after harvest, when the unmetalled roads were soft with rains and frost, and often impassable. The sheep-owners carted their wool down to the port, and took back their station-stores in the heat of summer, immediately after shearing, when every mudhole was baked to the hardness of brick.

Again, Port Cooper, now called Port Lyttelton, the principal harbour of the Canterbury settlement, was the crater of an extinct volcano, the sides of which rose precipitously from the beach, forming a formidable barrier to communication with the interior. This difficulty was partly overcome by rendering the Heathcote navigable, and by the construction of the Sumner Road; but its final solution was the construction of the Moorhouse Tunnel, which was opened for traffic December 9th, 1867.

The principal works executed by the Government were: 1st, The Sumner Road, from Lyttelton to Christchurch, which was scarped out of the cliffs for a continuous length of several miles. 2nd, The West Coast Road, from Christchurch to Hokitika, which was constructed in nine months, through 100 miles of rough and difficult country, totally uninhabited and, for the most part, densely timbered. 3rd, The Moorhouse Tunnel on the line of the Lyttelton and Christchurch Railway, 2,861 yards in length, driven through the crater wall of an extinct volcano, under a summit level 1,220ft. above the sea; and, 4th, The wharf and jetties at the Lyttelton station, built upon a soft mud-bank, which was, in places, 50ft. in depth.

In laying out roads on hilly ground, the principle uniformly adopted was to follow the windings of the spurs, contouring the gradients with the spirit-level, so as to minimise both cutting and embankment, and to dispense with culverts as far as possible. In the case of side cuttings, the gradient was contoured with the spirit-level and lock-spitted. The back line of the floor of the cutting was thus ranged out and the depth of the cutting measured at every half chain. The width of the slope was then calculated and set off, and the back line of the slope lock-spitted. The work could then be let by contract at any future time when the funds might be voted by the Council, no plans or sections being required, or any details, beyond the rate of slope, the total length of the cutting, and its cubic content. A serious difficulty in the conduct of the road works was the want of timber. The expedient adopted was to keep constantly in stock a quantity of planks, 16ft. 8in. long, and 8in. by 3in. in section, and the bridges and culverts were built on standard patterns designed with reference to this unit of material. This plan effected a great saving of office labour, as no drawings were required in ordinary cases, and as three planks made up 100ft. (board measure), any labourer was competent to take an account of the timber used, all that was necessary being to count the number of planks.

Amongst the road bridges there were few that presented special interest, with, however, two exceptions. These were—first, a drawbridge over the Waimakariri River, built on the telescope principle, from a simple design, and which worked satisfactorily; and, secondly, a bridge over the Taipo River, on the West Coast Road, presenting several peculiarities of construction.

The Harbour Works possessed considerable interest, which was enhanced by their partial failure. It was found that the mud-bank was too soft to support the screws of the screw-pile jetty, and accordingly, additional lengths of piles were cast, and a solid core of hard wood placed in the bottom of each pile, and driven down to the solid rock, on which the weight of the structure was made to rest; the flanges of the screws simply acting as supports to check lateral vibrations. The diagonal bracing was put in by divers without difficulty, the exact length of each brace being taken from a template applied by the diver to the work after the piles were screwed down to their proper depth. The sea-wall slipped forward in two places during the progress of the work, the total amount of forward movement in each case being between 5ft. and 6ft. The Author did not consider that any advantage would have been gained by carrying the piles down to the solid rock, as, in all probability, the outward movement of the embankment would in that case have overturned the work and destroyed it. He thought that the partial failure of the work might be attributed to two causes; first, that the stone embankment was deficient, both in bulk and weight, for the duty it had to perform; and secondly, that the tipping of the clay embankment was commenced before the stone embankment had had time to take a solid bearing, so as to form an abutment to resist the pressure of the backing. The work had since been completed, by driving an outer row of piles and putting in fresh capsills, jointing, and planking; and locomotives had been running for twelve months over the embankment without any further slipping, or more than the ordinary amount of settlement. It was worthy of notice, that no effect whatever was produced upon the seawall, or the jetties, by the great earthquake wave of August 16th, 1868, although the sea receded so as to lay dry a great portion of the harbour; and it might have been reasonably expected that the removal of the pressure upon the ground in front of the seawall would have been accompanied by the subsidence of the station ground. The breakwater was still in progress by prison labour.

The communication was accompanied by seventeen volumes of Appendices, comprising—1. Reports from the Provincial Engineers as to the progress of the Public Works; 2. Returns showing the cost of the Public Works, and the working of the Road Boards; 3. Papers relating to the Sumner Road, and to the Heathcote Navigation; 4. Railway Reports; 5. Reports on the Passes through the New Zealand Alps; 6. Reports on the encroachments of the Waimakariri River; 7. Papers relating to the Lyttelton Harbour Works; 8. Reports on the Telegraph Department of New Zealand; 9. Statistical Maps; 10. Topographical Maps; 11. Maps and Sections illustrating the several plans proposed for connecting Port Lyttelton with the Canterbury Plain; 12. Sections of the proposed Little River and Great Southern Railways; 13. Map and and Sections of the proposed Northern and Western Railways; 14. Drawings of the Timber Bridges over the Waimakariri and Taipo Rivers; 15. Drawings of the Moorhouse Tunnel, and illustrations of the progress of the Works; 16. Geological Section of the Moorhouse Tunnel, believed to be the first complete section ever made through the crater wall of a volcano; and 17. Views illustrating the Physical Geography of Canterbury.

In concluding this Memoir, the Author expressed the hope that, as a record of the engineering operations connected with the successful settlement of a previously uninhabited country, it might be found not only to possess present interest, but that it would become valuable as a record of precedents for future reference.

OCEAN STEAM NAVIGATION, WITH A VIEW TO ITS FURTHER DEVELOPMENT.

By Mr. JOHN GRANTHAM, M. Inst. C.E.

This paper, which was partly read at the meeting on the 7th ult., was concluded, and a brief abstract of the whole is now given.

The author stated that the object of his communication was, first, to take a review of the progress that had been made to the present time in ocean steam navigation; and, secondly, to draw from the examples thus collected some conclusions as to its probable development in the future.

It was contended that steam ships could be employed more extensively on routes partially occupied by them, and on others where regular steam lines had not yet been established. Rapid and regular voyages both for passengers and goods were now fully appreciated, while the greatly increasing intercourse of all nations furnished freights which would support lines of expensive steam vessels. The author traced the rise of ocean steam navigation, and showed that the route from Liverpool to New York was the principal field on which it was first fully developed. He described the efforts made by the Americans to maintain by steam the *prestige* so long secured by their sailing ships, gave the reasons for the great change that had taken place, and stated that not one American steamer was now running between England and America. Some of the causes of this were to be found in the fact that iron ships, worked by the screw propeller, could alone be employed successfully, and that such ships in America were too expensive, both in their construction and in the working, to enable them to compete with English vessels. The form of, and various improvements in, the boilers and the engines were described, showing that a much higher pressure of steam was now employed, that the expansive system and surface condensation were at present considered essential to success in economising fuel, and that the amount of coals consumed had in the best vessels been reduced to 2½lbs. per indicated horse power per hour, but it was anticipated that a reduction to 2lbs. might soon be attained. The engines for working the screw propeller had settled down into two forms—the vertical inverted cylinder, as used in the merchant service, and the horizonal cylinder, as applied in the Royal Navy. The great increase in the length of the hull was dwelt upon, and it was shown that this was essential commercial success.

A map on Mercator's projection was exhibited, indicating the principal ocean routes in connection with the trades between Great Britain and the rest of the world; and the improved system by great circle sailing, as recommended by Mr. Towson, of Liverpool, was described. A table was also exhibited of the relative distances between London and Liverpool, and the various ports shown on the map, both by long sea, and by the Suez Canal and the Pacific Railroad; from which it appeared that, as regarded the northern hemisphere, a great saving of distance and time would be effected.

The number of ocean steam ships now working in connection with this country was stated to be 364. The performances of the best ships of various companies was then alluded to, and the result showed that on the North American lines, the highest average rate of speed was maintained, but by a large expenditure of fuel; that the Pacific and Colonial Companies' ships gave excellent results as regarded economy of fuel; and that some new vessels, lately built for the Royal West India Mail Company, seemed to promise the best performances, with respect to speed and economy combined. With reference to ships engaged in the Mediterranean trade, particulars of their performance were given, and it was pointed out that great length, in proportion to the beam, had been extensively adopted, and very successfully in a commercial point of view. A brief statement was made relative to other large European steam ship companies, where good results had been attained, especially on two extensive lines between the North of Germany and North America. These vessels, however, were all built in this country.

From this branch of the subject the paper proceeded to give a table, taken from the board of trade returns for 1868, showing the amount of tonnage employed between Great Britain and all other countries in sailing and in steam ships. From this it appeared that, with North America, the tonnage of steam ships nearly equalled that of sailing ships; but in the Mediterranean trade, steam ships largely exceeded sailing ships. On the other hand, in the regular trades with India, China and Australia, steam tonnage, by long sea, comprised only about 1 per cent. of the whole. A calculation was then made to show what might be expected if the trade with the east was in future carried through the Suez Canal, and of the number of large steam fleets which would be required to work it. Some facts were also recorded relative to the effect of the Pacific railroad, and the probability of letters and passengers from China, Japan, and Western Australia going by that route. It was shown that several days' saving in time would be effected.

The author considered that the voyage to Melbourne could be best performed by long sea, as there would be no saving either in distance or in time by way of Suez. The paper held out great prospects of advantage to England and to British ship builders, from the immense changes that were apparently about to take place.

At the monthly ballot, the following Candidates were balloted for and duly elected as Members:—Messrs, J. W. Blackburne, F. Charlton, G. Gilroy, J. Knowles, F. Mathew, and H. F. Whyte A.B.; as Associates:—Messrs. J. Abernethy, jun., E. Armitage, G. F. Armstrong, M.A., J. H. Babington, J. Battersby, G. Blaxland, jun., A. B. Bradbury, F. Brine, *Major* R.E., E. J. Bristow, J. B. Cooper, J. Dixon, T. J. Ellis, A. Field, C. Flood, J. G. Gamble, L. A. Golla, F. B. Henslowe, A. S. Hewitt, W. Innes *Lieut* R.E., E. Lawrence, B.A., A. Leslie, F. Livesey, W. H. Long, J. W. Miers, J. W. Pease, M.P., C. Pollard, *Major* R.E., J. Prestwich, F.R.S., C. Prime, W. E. Rich, W. I. Roach, W. R. Scanlan, H. A. Taylor, C. Thwaites, H. C. A. Timins, R. H. Twigg, R. Vigers, H. C. E. Wenden, C. Wilks, A. F. Wilson, T. Wrightson, and A. F. Yarrow.

A Report was brought up from the Council stating that, under the provisions of Sect. IV. of the Bye-Laws, the following Candidates had been admitted Students of the Institution since the date of the last announcement: Messrs. E. A. Abbatt, J. V. Aguilar, R. D. Baillie, E. Bainbridge, G. H. T. Beamish, F. E. Burke, J. Cartmell, G. H. R. Deverell, G W. Fuller, R. N. Hodges, R. S. Hodgson, H. F. Joel, C. U. King, R. Lathbury, S. Lambert, P. W. Meik, W. I. Noad, G. W. Randolph, G. Remington, jun., J. C. Searle, J. Strachan, J. J. Talman, A. G. Tenghergen, C. Thomson, F. E. Townsend, A. W. Tyrrell, G. W. Usill, D. Wallace, J. S. Webb, A Wheatstone, and J. M. Wrench.

BRITISH ASSOCIATION.

AN IMPROVED VERTICAL ANNULAR HIGH PRESSURE STEAM BOILER.

By Mr. WILLIAM SMITH, C.E., F.C.S., F.G.S.

[*Abstract.*]

Although we have already given a plate and full description of Mr. Allibon's ingenious invention, we think it desirable to reproduce the drawings sent to the British Association, as several modifications have been introduced which will at once be evident upon a comparison of the two drawings.

This paper described an improved vertical high pressure annular steam boiler, recently invented by Messrs. Allibon and Manbré, and manufactured by Messrs. Allibon, Noyes and Co., of the Rosherville Iron Works, Northfleet, as it fulfils to a remarkable extent the conditions indispensable in a steam generator, and that, too, with an extreme simplicity of construction. Now the boiler stands by itself in this latter respect. The body of the boiler and the fire box are constructed separately as distinct parts, the water and flue spaces being disposed annularly. The outer part consists of the external skin or shell of the boiler, and a concentric inner cylinder is riveted thereto near the bottom, a wrought iron ring being interposed to keep the proper distance apart. This inner cylinder is also firmly stayed to the shell by screwed stays placed at suitable distances apart.

To the top of this inner cylinder a tube plate is riveted which is also connected to a central pendant annular waterspace, descending to within a short distance of the furnace bars.

Thus the fire box proper consists of two rings forming an annular water space round the furnace, the inner ring being made slightly conical to give a better heating surface, and at the same time permit the steam to get away freely. The top of this fire box is connected to the tube plate by a series of short lap, welded tapered tubes, screwed at both ends.

In the boilers first constructed on the Allibon and Manbré system, the central pendant portion was merely a receiver, pocket, or "pot," but in the boilers now constructed by them an important modification has been introduced to this portion of the boiler, the central portion forming part of the fire-box, to which it is connected by the short horizontal tubes or flue passages shewn at the top of the central pendant portion. The products of combustion on reaching the top of the fire-box are deflected by the upper tube plate, and descend between the outer ring of the fire-box and the inner cylinder or body of the boiler, until they arrive at the bottom, where they pass into an annular flue surrounding the base of the boiler, and from thence by an oblong flue or uptake to the chimney.

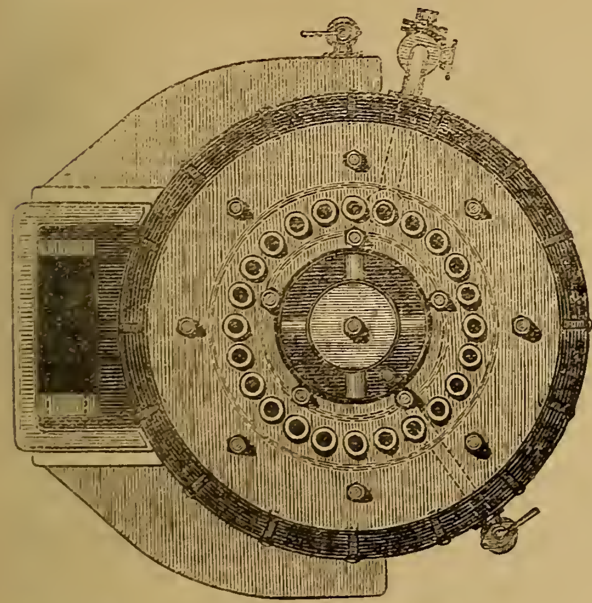
As a thoroughly scientific, yet simple construction of vertical steam boiler, this invention commends itself to the notice of all interested in the use of steam, and steam power, and should tend strongly to bring vertical independent boilers more generally into favour, seeing that their efficiency and safety in the boilers under notice are now greatly increased.

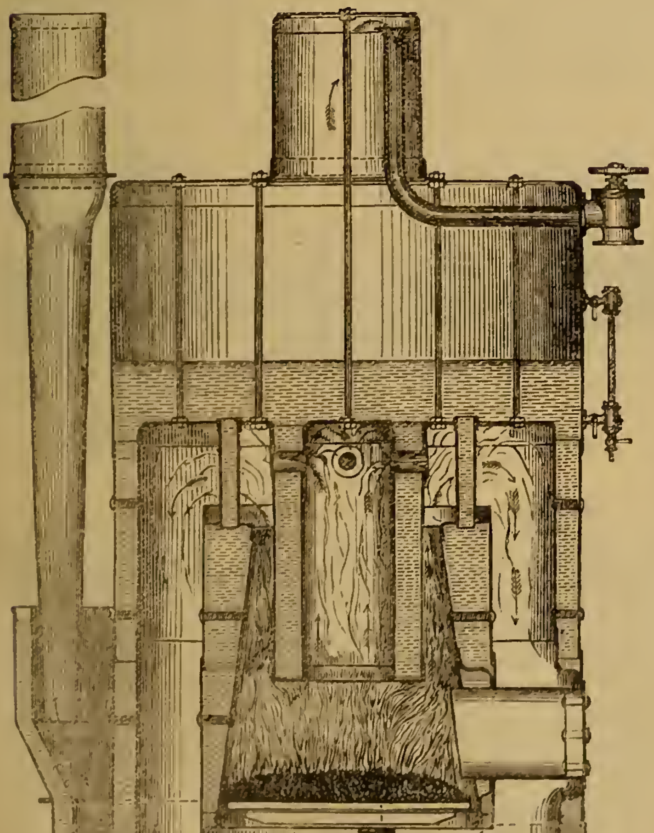
The flue passages are made sufficiently large to allow of their being cleaned easily out, and any repairs effected.

The annular flue surrounding the base of the boiler may also be converted into a feed water heater by jacketting or surrounding it with a water space.

The feed is pumped in by a circulating pump; a check valve and a relief valve being provided to prevent any excess of pressure.

This system possesses all the well known advantages of vertical independent boilers, rendering unnecessary the heavy item of expenditure for the setting of Cornish, and other enclosed boilers, whilst it allows of free inspection, and the consequent ready detection of leakage or other defects, and thus tends materially to diminish the risk of explosion.





Amongst some of the leading features of this boiler may be included the thorough circulation of water which is insured, the large extent of effective heating surface, the rapid boiling off of large volumes of steam, the thorough utilisation of the products of combustion, simplicity in construction of the several parts, and great strength of the whole as a steam generator.

When applied as a marine boiler, the advantages of this plan are very great, requiring only a very small space compared with the heating surface. Finally, the very good results obtained from boilers made according to this plan have fully realised the most sanguine expectations formed of its merits.

In the discussion which followed, it was admitted generally that the boiler referred to should, from its construction, prove a very rapid and economical steam generator. It was pointed out, however, that in the model, the amount of steam room, did not appear to be sufficient, in proportion to the steam generating power of the boiler, on the other hand it was stated, by the reader of the paper, that this could be easily increased.

ROYAL SOCIETY.

DEEP-SEA EXPLORATIONS.

At a meeting of this society, on Nov. 18th, the president, General Sir Edward Sabine, in the chair, Dr. W. B. Carpenter, V.P.R.S., presented a report of the results obtained by the deep sea explorations, conducted on board H.M.S. *Porcupine*, by Professor Wyville Thompson, Mr. Gwyn Jeffreys, and himself during the course of the past summer and autumn.

Referring, in the first instance, to the past history of such explorations, Dr. Carpenter mentioned the dredgings that had been carried on by M. Sars for the Swedish, and by Count Pourtalés for the American Government, as part of the ordinary work of the coast surveys of the respective countries. Near the Loffoden Islands M. Sars brought up from a depth of 300 fathams a small crinoid of a class that had been supposed to have no living representative. It was a *Rhizocrinus*, allied to the *Apiocrinite* type that flourished in the oolitic period, and that was supposed to have its last representative in the *Bourgetticrinus* of the chalk formations. To naturalists conversant with such matters, the discovery of this living animal was a fact as remarkable as the discovery of a living mammoth or plesiosaurus. It suggested the possibility that the process of chalk formation, which was believed to have long ceased, might still be actually going on, and in June, 1868, it led to a letter from Professor Wyville Thompson, containing the suggestion that the Admiralty should be asked to lend a crusier for the purpose of facilitating dredging operations of a kind that would be beyond the reach of private scientific enterprise. This suggestion commended itself very highly to the president and council of the Royal Society, and was by them pressed upon the attention of the Goverument. Capt. Richards, the hydrographer to the Admiralty, also cordially supported it, and eventually H.M.S. *Lightning*, under the command of Capt. May, was placed at the disposal of Dr. Carpenter and Dr. Wyville Thompson. The *Lightning* left Stornaway on the 12th of August, 1868, and cruised for five weeks between the north of Scotland aud the Faroe Islands, returning into Oban on the 21st of September.

Notwithstanding the short time devoted to the inquiry, the unfavourable weather encountered, the imperfections of some portions of the apparatus employed, and the difficulties, sometimes of an unforeseen character, inseparable from the commencement of a new undertaking, the cruise of the *Lightning* appeared to establish many facts that were not only new, but diametrically opposed to pre-existing beliefs. Philosophers had imagined that all life would cease at an ocean depth of 300 fathoms, and that the temperature of the deep sea was everywhere 39 deg. It was found, on the contrary. that abundant life existed at far greater depths, and that the deep-sea temperature varied within somewhat wide limits. More remarkable still, it was found that a difference in bottom temperature between 32 deg. and 47 deg. existed at points only eight or ten miles distant from each other, beneath a uniform surface temperature of about 52 deg.; and that where this was the case in the cold area the bottom was formed of barren sandstone, mingled with fragments of older rock, and inhabited by a comparatively scanty fauna, of an arctic or boreal character, while in the adjacent warm area the bottom surface was cretaceous, and the more abundant fauna presented characteristics due to the more temperate climate. Hence an upheaval of a few miles of the sea bottom subject to these conditions would present to the geologist of the future two portions of surface, totally different in their structure, the one exhibiting traces of a depressed, the other of an elevated temperature; and yet these formations would have been contemporaneous and conterminous. Wherever similar conditions are found upon the dry land of the present day, it had been supposed that the high and the low temperature, the formation of chalk and the formation of sandstone, must have been separated from each other by long periods, and the discovery that they may actually co-exist upon adjacent surfaces has done no less than strike at the very root of many of the customary assumptions with regard to geological time. The importance of these results, and the magnitude of the considerations springing from them, induced the Admiralty, at the renewed instance of the council of the Royal Society, to assist in the prosecution of further inquiries. Her Majesty's ship *Porcupine*, Captain Calver, R.N., was fitted up in the way suggested by the experience gained on the first expedition, and was provided with proper dredges for the deep sea, hauling-in machinery, deep-sea thermometers defended against pressure, and apparatus for the conduct of various chymical and other inquiries. She left Galway, under the scientific charge of Mr. Gwyn Jeffreys, on the 18th of May in the present year, and carried on the exploration in a westerly direction, getting into deeper and deeper water, until she reached the Porcupine bank, so named from one of her former surveys. She next proceeded in a north-westerly course towards Rockall, and thence returned to Donegal Bay. In this cruise the dredging and temperature soundings were carried down to a depth of nearly 1,500 fathoms. Early in July she started from Cork, under the scientific charge of Dr. Wyville Thompson, in a south-westerly course, for the purpose of carrying down the explorations to still greater depths, which were found at the northern extremity of the Bay of Biscay, about 250 miles west of Ushant. Here the dredge was successfully worked at the extraordinary depth of 2,435 fathoms, nearly equal to the height of Mont Blanc, and exceeding by 500 fathoms the depth from which the first Atlantic telegraph cable was recovered. She returned in about a fortnight, and started from Belfast in August for a third cruise, under the scientific charge of Dr. Carpenter, who was accompanied by Dr. Wyville Thompson. The object of this cruise was the more detailed survey of the ground previously examined by the *Lightning*, and the vessel remained out until September 15, visiting Thorshaven, in the Faroe Islands, and Lerwick. The results of the three expeditions went entirely to confirm, and in many respects to enlarge, the conclusions that had been drawn from the more limited surveys of the preceding year.

Dr. Carpenter commenced his account of the actual work done on board the *Porcupine* by a very warm tribute to her commander, Captain Calver, who brought to the work the most complete and untiring devotion, a large amount of experience, great ingenuity and sagacity. The working of the dredge at the great depths attained was entirely due to Captain Calver's skill, resources, and good management, and nothing could have been more complete than the success of the various contrivances which he suggested from time to time. On many occasions a dredge weighing 8 cwt., and carrying $1\frac{1}{2}$ cwt. of mud was brought up without a hitch from a depth of nearly 2,500 fathoms.

The thermometers employed for measuring deep-sea temperature were of a pattern invented for the purpose by Professor Miller, and made by Mr. Casella, In all previous researches of the kind, ordinary thermometers have been used, and these are not only very liable to fracture, but they also rise under pressure, and the readings from them require correction on this account. The Miller-Casella thermometer, on the other hand, was tested under a pressure of three tons to the square inch (corresponding to that of an ocean depth of 2,400 fathoms), prior to the departure of the expedition, and showed no more change than a rise of about one degreee, which was due to the actual increment of heat arising from the pressure itself; while so strong were the instruments that two of them were in constant use, without injury, throughout the whole of the expedition. The temperature was taken both by serial and by bottom soundings; the former being repeated every 50 fathoms, or even more frequently, down to a depth of 300, and every 100 fathoms at greater depths. The surface temperature varied a good deal with differences of latitude and season; but, when high, declined rapidly, and was lost at about 100 fathoms. From hence, in deep water, there was rapid decline to about 1,000 fathoms, at which a temperature of 38 deg. was found; and at 2,435 fathoms there was a slight further fall to 36·5 deg. Compared with this comparatively elevated temperature it has been found that the deep sea temperature in the Arabian Gulf, and even under the Equator, is very low, falling to about 30 deg., or even lower; so that the general temperature of the deep tropical seas is less than that of the North Atlantic basin. On the other hand, the bottom temperature of certain parts of the channel between the Faroe Islands and the north of Scotland sunk to as low as 30 deg., while at the same depth in adjacent localities it was as high as 43 deg. In the colder area it was found that the temperature fell rapidly between 150 and 300 fathoms, to remain almost stationary below the latter depth; and the general result of the thermometric observations was to show the existence of a stratum of ice-cold water from 300 fathoms downwards; a stratum of warm water for about 150 fathoms from the surface, and a stratum of intermixture between the other two. The cold area occupied nearly the whole of the actual channel between the Faroe Islands and Scotland, but a higher bottom temperature was found along the east side of this channel, near the so-called 100 fathoms line which marks the commencement of the ascent to that plateau of which the surfaces form the British Islands. In order to illustrate the conditions on which these facts of marine temperature depend, the hydrographic department of the Admiralty had prepared a large map having the North Pole as its centre. On this map Dr. Carpenter pointed out that the Arctic Ocean was almost entirely inclosed by land. It possesses a narrow outlet at Behrings. Straits, and some circuitous channels leading to Baffin's and to Hudson's Bay's There is also a deep channel between Iceland and Greenland, through which flows a powerful current; but between Iceland and the Faroe Islands there is a submarine ridge, rising to within 200 or 300 fathoms of the surface, and forming a complete barrier to the southward course of deep sea water. Only at one point, near the north-east corner of Iceland, is there a deeper channel, reaching to about 600 fathoms, with a bottom of volcanic sand. Between Shetland and the Scandinavian peninsula there is another ridge or barrier, on which the depth nowhere exceeds 200 fathoms; and hence the deep channel between the Faroe Islands and Scotland, the channel close to the eastward of Ireland, and that between Iceland and Greenland, are the only feeders of the deep Atlantic with ice-cold water, which necessarily traverses their greatest depths in a steady southerly current, carrying with it the *debris* of the region from which it comes, sustaining its appropriate forms of animal life, and displacing other forms for which a higher temperature is required. Dr. Carpenter dwelt at some length upon the various currents hence arising, and upon the great changes that would occur in the deep temperature and in the fauna of the Northern Atlantic if the barriers described should ever be sufficiently broken down to allow of a free efflux of deep Arctic water such as is experienced now from the Antarctic towards the Equatorial region.

Leaving the subject of temperature, Dr. Carpenter next spoke of the extraordinary abundance of animal life at the bottom of even the deepest ocean abysses. Over the whole of the warm area explored the bottom was found to be covered with globigerina deposit—that is, with animal life actively engaged in chalk formation. In the colder area the globigerinæ are not found; but here is a bed of volcanic sand, which forms the paradise of the northern echinoderms. From the most profound depths animals of high organization, and with perfect eyes, have been brought to the surface by the dredge, and the creatures discovered include an extraordinary collection of siliceous sponges and foraminifera, together with zoophytes, echinoderms, molluscs, annelids, and crustaceans. One hundred and twenty-seven species of mollusca not previously known to exist in British seas were among the captives, and a large number of these are altogether new to science. The expedition has nearly doubled the number of British echinoderms, and at one spot, where the dredge brought up little or nothing, and where Captain Calver devised a plan for sweeping the bottom with hempen tangles, the first haul of these tangles secured, at a moderate estimate, 20,000 specimens of a single form of echinus. In the cold area *arenaceous foraminifera*, creatures which construct habitations by the agglutination of particles of sand, were so abundant that it will be difficult to find names for the new varieties; and a chymical examination of their cases confirms the inferences about the cold current that were drawn from thermometric observations, by showing that these cases are formed from particles of northern volcanic detritus. Many new sponges, some differing widely from previously known varieties, were also discovered; and at the next meeting of the Society Dr. Carpenter purposes to exhibit to the Fellows a collection of the treasures of the deep that have thus unexpectedly fallen into his hands.

During the progress of the researches sea-water was brought up from various depths for chymical analysis; and attention was early called to the character of retained gases. Near the surface it was found that the gas consisted of about 24 or 25 per cent. of carbonic acid, the rest being chiefly oxygen and nitrogen, but at greater depths the proportion of carbonic acid greatly increased, and reached 45 per cent. at 700 fathoms. After storms of wind, however, by which the surface of the ocean had been much agitated, the quantity of its carbonic acid was very much diminished. In one of the surface specimens taken scarcely any was found at all, and its absence was at first set down to some error in analysis. Afterwards, however, it was remembered that this water had been dipped up from abaft the paddles of the steamer, and not, as usual, at the bow. The inference from these facts is that the agitation of the sea by storms, by liberating its superficial carbonic acid, and thus permitting the ascent of that which is constantly formed by the abundant animal life below, furnishes one of the conditions which render the continuance of that life possible.

The inquiry into the sources of food for the deep-sea animals resolves itself into the single question of the maintenance of the globigerinæ, or chalk animalcules. Directly, or indirectly, all their neighbours can live upon them, but it was at first difficult to conjecture how they could live themselves. Professor Wyville Thompson has suggested that they may be supported by the organic matter diffused through the deep sea water, and analysis has shown that such organic matter is present in considerable quantities, and in assimilable, as as distinguished from decomposing forms. Besides the analyses conducted on board, some specimens of water were brought to Professor Frankland, and he has fully confirmed the conclusions that had been reached.

Dr. Carpenter's address was received with very cordial applause by a crowded meeting. It concluded at so late an hour that any questions or discussion upon it were postponed; but Sir Charles Lyell gave expression to the thanks of the society. He observed that the perfect eyes of the deep sea animals suggested the probability of their having a phosphorescent *habitat*, and said a few words upon the astonishing, and, to geologists, almost revolutionary character of the discoveries which Dr. Carpenter had announced, and in which he had had so large and so honourable a share.

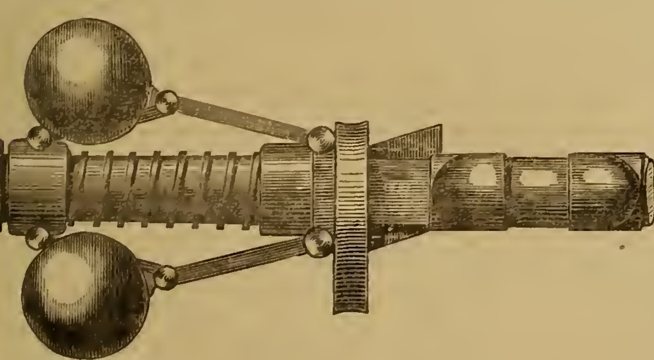
THE SMITHFIELD CLUB SHOW.

It has been a common remark for many years past that a person having once visited this annual show ought to know as much as if he had made a point of going to it every year. As far as the general features of the show are concerned this is undoubtedly correct, but a careful observer who wanders year by year through the multifarious exhibits is sure to be attracted by some not unimportant novelties, or improvements, amongst every fresh collection of machinery brought together at the Agricultural Hall. Last month's exhibition certainly appeared at first sight as if the collection of implements shown in December, 1868, had never been removed; the same names and apparently the same machinery being stationed in almost exactly the same place. All the well-known makers were as usual in full force, but in most instances but little, if any, difference from the past years' exhibits can be found with the exception, perhaps, of a still greater perfection of finish. Thus, Messrs. Clayton and Shuttleworth, of Lincoln, in addition to their usual excellent collection, had on view a small horizontal engine, with a separate expansion valve worked by an independent eccentric, which from the style in which it was finished appeared to be intended to drive some equally highly finished machinery in a drawing-room. The use, of such an amount of bright work in so small a space can only be accounted for by the supposition that, from the perfection of workmanship the driver would have too little employment if he had not constantly to rub up such a mass of polish. Most of the other well-known makers were content with even less of novelty. The Reading Iron Works had a fine show of machinery similar to last year, and for many years before that; Messrs. Ransome and Sims appeared to be similarly situated, as also Messrs. Garrett, Messrs. Marshall and Sons

Messrs. Tuxford, and other well-known makers, with their equally well-known engines, both fixed and portable. Messrs. John Fowler & Co. had as usual a splendid collection of steam ploughs, and their rivals, Messrs. J. & F. Howard, also had on view their peculiar transverse boiler arrangement of steam ploughing engines. Of traction engines there was the usual collection; Messrs Aveling and Porter shewing one of their old design, which, we think, has not as yet been surpassed by any other maker. Mr. Charles Burrell, who may be considered one of the fathers of traction engines, exhibited one of his well-known type, with the addition of spiral springs for the purpose of mounting it, but we fail to see the advantage of such an arrangement. Messrs. Garrett as usual exhibited one of their traction engines driven by a pinion working in an internal toothed wheel attached to the hind wheel of the machine, an arrangement which can scarcely be recommended for rough work. Amongst the few novelties in the show the principal are directed towards the economy of fuel in portable engines; although there are a few which appear to aim more at economy in their production. For instance there were several different arrangements for obtaining variable expansion—a point which seems to have attracted increased attention during the past few years.

Messrs. Ruston, Proctor, and Co. had several engines fitted with a variable expansion gear, on Chapman's patent of 1866, which they state has already been fitted to more than six hundred engines. It consists of an eccentric fitted loose on the crank shaft, but bolted to a fixed disk thereon. The bolt by which the eccentric is fastened passes through a slot in the disk, and can be moved at pleasure; such movement being imparted to the eccentric and varying the cut off. A somewhat similar arrangement is adopted by Messrs. Marshall and Sons, the only difference being that the eccentric is slotted out, so that it can be shifted transversely across the crank shaft, and is held in the required position by means of a bolt working in a slot in the fixed disc. This arrangement, which is patented by Messrs. Hartnell and Guthrie, is also said to have been very extensively adopted. Messrs. Tasker and Sons vary their arrangement by having a number of bolt holes in the disc instead of a slot for shifting the eccentric. As regards these arrangements, there is no doubt but that they are exceedingly useful for altering the expansion according to the work which it is known that the engine will have to perform for some considerable period; but for threshing, sawing, ploughing, or any similar work where the strain is constantly variable, it would be ineffective. It is rather astonishing that the plan of shifting the valve eccentric by means of a slotted fixed disc, which has been known for such a long time, should not have been before applied to agricultural engines, when intended sometimes to work to their full power, and at other times to perform mere nominal work.

Passing from these systems, where the engine has to be stopped for the purpose of shifting the eccentric, we come to a very excellent arrangement shown by Messrs. Roby and Co., where the eccentric is shifted by means of the governor, and is consequently a self-acting variable expansion gear. The accom-



panying illustration will at once enable our readers to form a correct idea of the method adopted by Messrs. Roby. It will be seen that the shaft where the eccentric is placed is made square, and fitted with wedges upon which the eccentric slides. It is, in fact, the same as Dodd's wedge motion, which, until replaced by the link motion, was so commonly used on locomotives as an expansion and reversing gear; only in this case it is used simply for expansion: that is to say, that the wedges only vary the forward throw of the eccentric from full steam to nothing, or as little as may be requisite. These wedges instead of being worked by hand, are attached to the governor. This is effected by means of two links, one end of each being connected to the governor arms, and the other end to a collar round the shaft attached to the wedges. As the governor balls diverge, the arms draw the wedges through the eccentric, and in doing so shift it from the position which it occupies when in full gear; the effect being that the greater the divergence of the balls the more the throw of the eccentric is reduced and the earlier is the steam cut off, the lead, however, remaining constant. On the contrary, when the speed of the engine is reduced the balls are drawn towards the crank shaft by the action of the spiral spring interposed between the fixed and moveable collars, and the throw of the eccentric is increased by the corresponding movement of the wedges. The range given on the engine we are describing is such that the point of cut-off can be varied from $\frac{1}{8}$ to $\frac{3}{4}$ of the stroke, the point at which suppression occurs in the course of regular work being about $\frac{1}{4}$ of the stroke. At first sight it appeared doubtful whether the defects noticed when working a link expansion gear with an eccentric would not be reproduced in this case—we allude to that peculiar opening and closing of the governor arms at each stroke of the eccentric rod, somewhat like a bird flapping its wings. Messrs. Roby state, however, that by giving the wedges a sufficiently easy slope, such as $2\frac{1}{2}$ to 1, all such motion is avoided, and that the governors work with the greatest facility. We understand that this expansion gear has been patented by Messrs. Roby and Richardson.

Messrs. Brown and May had on one of their portable steam engines a peculiar arrangement for heating the feed water by forcing it through a jacket surrounding the exhaust steam pipe. They say that by this means the feed water is raised to the boiling point, but in order to raise the temperature to that extent, we think the steam must have to pass out of the cylinder at too high a pressure.

Messrs. Tangye Brothers and Holman had a very complete set of small engines arranged somewhat after the American fashion with, if we may so term it, the bed plate at the side of the engine, as introduced by Mr. Porter. The donkey pumps made by this firm, were also well represented, but these are too generally known to merit any special attention.

In the miscellaneous exhibits there was scarcely anything new, the only important novelties, if such they may be termed, being several plans for dressing millstones by the use of diamonds. The one that we saw at work had a revolving cutter, the diamonds being fixed round a circular head, this cutter being traversed in the usual method, with the exception of the revolving cutter there did not appear much novelty in the in the arrangement, and we fear that the concussion to which the diamonds must necessarily be subject when revolving at a high speed will very frequently break them. In another place we illustrate an American stone dressing machine which has been in use for many years, and which will explain the principle upon which nearly all the others are founded. We ought not to omit favourable mention of a machine for sharpening the knives of reaping and mowing machines, which was to be seen at the stand of Messrs. Hornsby. It appeared remarkably simple, easily worked and very efficient—in fact just such a handy little tool that an agricultural labourer could appreciate.

PATENT LAW.

THE BOVILL LITIGATION.

(*Continued from page 284.*)

In November, 1867, the suit of Bovill v. Smith was brought on for hearing before Lord Hatherley, then Vice-Chancellor Wood.

In order to appreciate his Honour's judgment it is proper our readers should be reminded that the only words of instruction in Mr. Bovill's specification by which millers were taught how to do a new thing were these: "When working millstones with a blast of air I introduce a pipe to the millstone case, from a fan or other exhausting machine, so as to carry off all the warm dusty air blown through between the stones to a chamber, as hereafter described, by which the dust in the mill is avoided, and grinding improved, and this part of my invention relates only to sucking away the plenum of dusty air forced through the stones, and not to employing a sufficient exhausting power to induce a current of air between the millstones without a blast, this having been before practised." And that they should know that Mr. Bovill, in his English patent of 1846, published an arrangement for employing exhausting power to get the desired current of air through the grinding surfaces of the millstones, and at the same time avoid the inconvenience of passing the meal through the exhausting machine; and that in 1846, a Mr. Debeaune registered under the Utility designs Act, a plan of a set of millstones arranged round a central receiver, from the top of which a fan was to carry away, by exhaustion, the stive. The inconvenience sought to be avoided by Mr. Bovill's English Patent of 1846 was one supposed to attend the working of Newton's earlier patent of that year, whose drawing showed the exhausting apparatus attached to the meal spout itself, so as to draw both meal and air through the grinding surfaces, and discharge both from the fan into a receiver. Mr. Bovill proposed to draw air through the grinding surfaces by exhaustion, but to avoid passing the meal through the exhausting apparatus, whilst Debeaune proposed to use the exhaust only to draw away the stive from the receiver without seeking to increase the current of air between the grinding surfaces.

The defendant in Bovil v. Smith used exhausting power only to draw away the stive from the millstone cases, and to blow it either into the open air, or into a a non-porous stive room.

It will be necessary to transcribe portions of the evidence, as the besetting infirmity of the Court of Chancery as a tribunal for deciding on the validity of a patent exhibited itself so plainly that parts of the evidence were not read by the learned judge until he was pronouncing his judgment, and other parts of it were sadly misunderstood.

It will be recollected that in Bovill v. Crâte the judgment in Bovill v. Keyworth was referred to as not in any way binding upon the Court of Chancery, but we shall soon see to what extent that Court's investigation of the questions was an independent one.

The Vice-Chancellor: "Mr. Grove, I do not think I need call upon you in this case for a reply. I am of opinion that the arguments which have been adduced before me have not touched in any way my judgment in the case of Bovill v. Crate, nor have the circumstances which have been adduced in evidence here as being supposed to shew some degree of distinction between this case and Bovill v. Crate. It appears to me, when it comes to me to be analysed, that neither the new evidence nor any of the new arguments—I should rather say, arguments put in a new form—ought to make any difference in the case. What I apprehend to have been the contest in Bovill v. Crate was this:—The defendant of course, was compelled to admit that in Bovill v. Keyworth there had been a decision on the general validity of the plaintiff's patent in that particular case, that that decision had been come to after a very mature consideration, and that that consideration had been given to the case not only by the then Lord Chief Justice Campbell, who tried it, but by the Court of Queen's Bench on the motion for the new trial; and it appeared to me there was one very important point determined in that case which I was not at liberty to dispute, if I had been inclined to do so, and I certainly was not inclined to dispute it. That point was just this: The patent in Kay v. Marshall seemed to me rather a nice point upon this particular enquiry. In Kay v. Marshall, it was determined that if it has been ascertained that an advantage is to be procured by doing a certain act, such as in that case the bringing two parts of the machine to a nearness with each other, you could not, because you ascertained precisely the exact point at which the best effect was produced, have a special patent for that, it being known beforehand that bringing the two things near was a matter of great importance. As to that there could have been a patent if they had never been used near before, but at a given distance off, but persons being at liberty to move them to any distance they pleased in the experimental process, in order to see which was the best, you could not by alleging you had found the best number of inches to accomplish the result, on that ground alone obtain a patent. The argument, of course, upon this case of Bovill's patent would be:—the blast having been used before, the exhaust having been used before (as you admitted by your own patent), and as in fact it is clear upon the evidence had been done, you cannot obtain a patent for saying, 'Well, but use the blast, and use the exhaust, and use them in this particular mode—exactly with this amount of judgment, namely, that the plenum only, that is to say the excess of blast (if I may so use the phrase), shall only be removed, and you shall take care not to work your exhaust to such an extent as to create any blast whatsoever by the stones, supposing all other blast were away." It was said you cannot have a patent for that, because that merely is hitting upon the process alone in which a matter may be done which it was admitted had been done before, but had not been done, perhaps, quite so well, because the exact line had not been hit upon. It does appear to me, Bovill v. Keyworth distinctly decided that the patent was not open to the objection which arose in Kay v. Marshall, and that the patentee (as Lord Campbell described it), by having described what he does, namely, the exhaust of the plenum, and having cautioned you not to do more, has made a valuable discovery, proved and established as it was in that case by evidence, and as has been proved abundantly before me by evidence in both cases of Bovill v. Crate, and Bovill v. Smith, to have been a vast improvement, and therefore a proper subject matter for a patent, inasmuch as it was not a mere idea by which parties were to be guided, but an idea brought into material action by your telling the parties what is to be done. A second point was at the same time also determined in Bovill v. Keyworth, namely, that when be used those words, 'exhaust the plenum, but do not use your exhaust sufficient to produce a blast,' the Court was of opinion, and I do not find that in substance disputed (I shall presently comment on there being no blast at all) that there was enough to lead any experienced mechanic to know what to do; that, in truth, the thing had been easily done from the description so given; and when Lord Campbell asked the Counsel to devise a better form of words, they confessed themselves unable to do so. I said, on the former occasion, that that case, being a case in which what is called an artificial blast was used—that is to say, something beyond the mere blast produced by the rotation of the stones in the ordinary manner, which had existed ever since millstones had been known and used—that case being a case in which such an artificial blast had been used, of course the judgment of the Court, and any effect which was due to that judgment, must be confined to what the Court had before it. If I had a new state of facts before me, which to a certain extent I have, and which I had in Bovill v. Crate, I must apply my mind to that new state of facts to see how far the circumstance of there not being an artificial blast in this case, but the blast created by the mere rotation of the stones, ought or ought not to produce a variance in the decision at which the Court may arrive.

"Now then, in Bovill v. Crate the great contest was, as to which in some of the arguments (especially Mr. Little's argument I may say) that contest has been repeated, although I find the evidence upon it exceedingly small that there was no blast at all when you used the stones in the ordinary way; Mr. Little repeated that again, he said 'there cannot be a plenum,' and finding that the plaintiff did not describe his improvement until he came to that part as to exhausting the plenum, Mr. Little said 'there is no plenum to be exhausted if there is no blast;' now that, I say, was the great point of the case in Bovill v. Crate; that was the point upon which we had a great deal of evidence. I must say, Mr. Bramwell never gave any evidence in that case as he has not given it in this, saying, that no blast is produced by the ordinary rotation of the stones one upon another. I should have been much surprised if he had, but he contented himself with saying, 'if a plenum can be created in that way,' he does not say it cannot, and I do not therefore repeat what I said in the first part of my judgment, before you arrive at what Mr. Little commented upon, and very fairly commented upon, by way of argument to shew, that in my judgment there is a distinct blast beyond all dispute, that there is a blast created by the ordinary rotation of the stones, what one witness, Dr. King, calls the 'innate' blast, which is an odd expression, but it is in fact a blast created by the rotation of the stones, and of course if additional blast is occasioned a plenum may be created, that plenum may be exhausted, and that exhaustion may be carried to the extent only of exhausting that surplus of air which is so induced by the ordinary whirling action of the stones. When that is done you are to take care not to draw off any more, and the whole thing described by the plaintiff in his patent takes place, namely, you exhaust the plenum and you do no more."

The passages of the printed evidence to which reference has been made were as follows:—

"I say that I observe at paragraph 40, 42, and 48 of the plaintiff's bill of complaint that the plaintiff in effect states the second part of his invention (that relating to the exhaust) to embrace cases where an exhaust fan is applied to millstone cases regulated so as to carry off what is termed in the bill 'the plenum of air' although there be no fan or other blowing machine applied to such millstones, and that to support this statement be, in the 10th and several other paragraphs, alleges that the revolving millstone itself is such a blowing machine as was intended by his specification, and I say if these contentions of the plaintiff be correct then his specification is calculated to mislead a mechanic, and is not sufficient to inform him where he is trenching on the plaintiff's alleged invention, for I say that a mechanic reading the said specification and finding there the statement that the plaintiff's invention consists ' in exhausting the air from the cases of millstones, combined with the application of a blast to the grinding surfaces,' and also finding there in reference to the same invention the words 'In carrying out the second part of my invention when working millstones with a blast of air I introduce a pipe to the millstone case from a fan or other exhausting machine so as to carry off all the warm dusty air blown through between the stones to a chamber' would not understand that such words intended a blast of air produced by the mere revolution of the stones, because if this were the meaning of that passage, the words, 'when working the millstones with a blast of air would be not only unnecessary, but would mislead, since it is, according to the plaintiff's present contention, impossible to work millstones without a blast of air, whilst on the other hand if it be possible to work millstones without a blast of air there is no direction anywhere given how to apply the exhaust when working in that manner."

"6. According to the construction of the plaintiff's specification contended for in the case of Bovill v. Goodier the plaintiff is supposed to have patented the application or use of an exhaust from the cases of millstones in two forms as well as the use of an exhaust in combination with or as a supplement to the super-added and artificial blast namely (first) the form of working the exhaust in combination with the innate blast of the stones themselves and (second) the working of the exhaust in such a manner or degree as to take away from the millstone case the plenum in the millstone cases and no more. This innate blast of the stones is the displacement of air caused by the alleged fan or blowing action of the running stone and this so-called plenum of air is the volume of air in the millstone cases heated and disturbed by the friction in grinding and by the rotation of the running stone. According to the 46th paragraph and the 48th paragraph of the plaintiff's bill in this cause the 'carrying off by an exhaust the warm dusty air from the millstone cases" is exhausting the plenum as mentioned in the plaintiff's specification, I mention the following reasons why an engineer reading that specification would form the opinion that the process of exhausting the plenum described in the specification is the use of an exhaust as a corrective supplement to an artificial super-added blast ventilating the grinding surfaces of the stones, and is not any one of the three things which as I have stated the plaintiff contended in the case of Bovill v. Goodier and intimates in the 46th paragraph of his bill amount to exhausting the plenum. To an engineer the very expression ' to exhaust the plenum of air forced through the stones" imports that a superadded artificial blast is employed to force the air through the stones because as indeed is stated in the plaintiff's own specification under his English patent of 1846 (I refer to page 3 line 32, to page 4 line 3 of the printed copy) without such a blast it would be impossible to have a plenum between the stones for a plenum is nothing else than a volume of air in a particular place at a higher pressure than the normal atmospheric pressure.

Moreover to an engineer the expression 'when working millstones with a blast of air' contained in the plaintiff's specification of 1849 imports that an independent blowing machine is being employed to force air into the millstones, and in support of this statement I would refer to the obliterated words to be found at page 7 line 33 of this specification as shewing a recognised and well understood difference between working millstones with currents of air produced by a blast and by an exhaust, and without wind in the ordinary manner. I further say that the signification which I have stated the expression 'to exhaust the plenum' conveys to an engineer makes it an equivalent for the expression used on page 7 lines 5 and 6 of the specification namely 'exhausting the air from the millstone cases combined with the application of a blast of air to the grinding surfaces' and for the words in the immediate context of the expression itself as to carrying off by the exhaust all the warm dusty air blown through between the stones when working millstones with a blast of air, and that in each of these expressions the ventilation of the grinding surfaces of the millstones is indicated as an essential matter, and therefore, that an engineer would not understand that the plaintiff was by any words in his specification claiming the use of an exhaust which would not ventilate the grinding surfaces. And I mention as a good cause for the plaintiff adding this expression as to exhausting the plenum to the preceeding words for which I say it is an equivalent that it was known to the plaintiff at the time of preparing the specification that the double object of ventilating the grinding surfaces and removing the stive had been previously accomplished by using the single agency of an exhaust alone, and it was therefore necessary for him to intimate that his present invention was one for effecting that double object by employing two agencies, one the blast to ventilate the grinding surfaces and the other the exhaust to remove the stive, and I say that there may be very considerable advantages to a miller in accomplishing this double object by the employment of the two agencies as in my opinion the blast accelerates the work of grinding far more than the exhaust can do so."

The Vice-Chancellor proceeded:—

"Now again in Bovill v. Crate there was a great deal of argument on this, which I have heard repeated here on the present occasion; if you look at the whole of the plaintiff's patent, especially that portion on which I remember the argument in the former case has been repeated in this case, that portion which has been struck out by disclaimer, but which may be used as shewing the sense in which the patentee used his own language, you will find there, in that particular portion of the invention first described, three modes of working it, the one with the blast, the other what he calls without wind (that is the ordinary way, or at least it is to be presumed so, and I read it so), the other by means of an exhaust. He points out those three modes, and when he comes to describe his own invention, having given you those modes of operation, which the argument is he intends to describe, they are, three distinct and separate modes, the one being the blast (and the word 'blast' must mean artificial blast) and the other being without artificial blast, the third being the exhaust, he says, 'in carrying out the second part of my invention, when working millstones with a blast of air I introduce a pipe to the millstone case from a fan or other exhausting machine,' and then comes the other part, which I have always relied upon as that which describes his invention, 'and this part of my invention relates only to sucking away the plenum of dusty air forced through the stones, and not to employing a sufficient exhausting power to induce a current of air between the millstones without a blast, this having before been practised, as above mentioned.' Now then, it is said that here you have had the evidence of his own language, which tells you he is not looking to the working of the stones in the ordinary manner without an artificial blast, and that that being so the claim must be limited to the using of the exhaust when you use the artificial blast; that is further proved by the evidence put in in Bovill v. Keyworth, which evidence undoubtedly shows over and over again that in the words he uses here he claims exhaustion in combination with a blast. I had to comment upon that at considerable length on the former occasion, and therefore I do not go into it now, simply saying, in the first place, that I had the opinion of the Master of the Rolls—that opinion distinctly concurred in by Mr. Justice Willes—that there is nothing in this patent to confine the patentee to the working of an artificial blast, and I concurred in their opinion on two grounds. First, I said that it would be in my judgment, to say the least of it, very questionable whether under this word 'blast' you could say it necessarily means artificial blast, although his own working of it in his own mind was a working with the patent which he had obtained in 1846, similar to the one which had been obtained by Mr. Gordon about the same time for working it with an artificial blast. Although that may have been passing in his mind, just look at the history of the transaction (I do not enter into the details of it, for it is all explained in the defendant's Answer). The whole matter seems to come to this, there were two inconveniences occasioned, and I noticed this particularly with reference to an argument of Mr. Webster's, about this being a patent for 'improvements in manufacturing wheat and other grain'—there were two inconveniences, not merely the flying about of the dust, which was an inconvenience, but as regarded dirt, and still more important because it was inconvenient to the workmen in reference to their health, having a quantity of dust in the atmosphere in which they were condemned to live, but also as the defendant puts it in his answer, there was the inconvenience from the heat of the meal; the effect of the heat and the moisture combined was this, that the meal came out in a clammy state, and that inconvenience was a very serious one. You have all men's minds who were concerned in this business directed to correcting these two inconveniences, directing their attention to avoiding them—namely, the heat and moisture on the one hand, which tended to damage and spoil the meal, and the preventing its flying about the mill, which was found to be a great inconvenience in another direction. People's minds being directed to that, the first improvement you had was that of improving the blast which effected what was desired in cooling the meal, but at the same time had the effect of driving the stive out in a manner very much worse than before. Well, that being so, next came another way of doing it. It was thought you might have this blast used in the shape of an exhaust, instead of being used in the shape of a blast (that was Newton's blast), and so create a draught, which of course you would do by the inverted action. That was found to have its own inconveniences also. The exhausting plan was found inconvenient, and it was found that it would not work in consequence of its having too much effect on the meal in the pipes, the meal not flowing out of the spouts in the way desired; at all events it would not work. That being so, we have evidence in abundance that there were people in England, and people in France, trying all they could to avoid these inconveniences; at last, you find the plaintiff does do it, and the moment the plaintiff does do it it, as usually occurs, everybody says it is exceedingly easy, and everybody must have known it. However, the plaintiff does it, and it is successful, and it consists of the simple operation of just using the blast and the exhaust in such a manner that the surplus, or plenum, should alone be drawn off, and, when it is drawn off, you must not carry your exhaustion one single step further; you will not create the inconvenience which Newton's occasioned, and you will obviate the other inconveniences of Gordon's, and so on, because you will withdraw the plenum and prevent that scattering of the stive about the mill which prevented your working in the manner desired. The great object of all parties in all these things was to grind a greater quantity of flour by the rapid motion of the stones, but until you cooled the meal it was found impossible to work the stones with the number of revolutions you desired because by doing so you increased the heat; you were obliged to confine yourself to a certain amount of revolutions. It was not until the plaintiff's patent came out that you found you could get an increased number of revolutions. When that came out, you got rid of the stive, and heat, and moisture, and everything was brought into that state which is represented in that report which was made by those persons, who, on behalf of the Government, tried the plaintiff's process. I put it in my former judgment, and I say I adhere to that most fully, that in whatever way you choose to read the word 'blast' in the description contained in the direction I have referred to about the second part of the plaintiff's invention, whether you even read the word blast where he uses it, as meaning an artificial blast, or whether you read it as meaning a blast generally, it seems to my mind to make very little difference. What he says is this, that if there is a blast, he draws off the plenum. He does no more; and he tells you he uses it when he is using, say his artificial blast, but does that prevent it also including the case of an ordinary blast? It is just this:—First, there is an ordinary blast (I have already given my reasons for holding that), and secondly there is an increased blast. I think the increased blast the best mode of working; therefore, when I am describing my improvement in just hitting that exact happy medium in which the plenum shall be drawn off, and the draught shall not be increased, I am describing my application of it to the best mode of working, and the best mode of working I conceive to be working with an artificial blast. Does that prevent him saying my invention is exhausting the plenum, and not doing more by way of creating a blast? There is the invention, and of course there is a plenum created by the ordinary blast. His telling you that he applies it to the best mode of working, will not prevent his describing it being applied to the mode in which blast is employed, whether by the ordinary operation of the stones or in any other manner. It comes to this. A man might just as well say, 'Well, now, the plaintiff, when he worked with an artificial blast, worked it up to such a degree of pressure. I do not work it to that degree of pressure; I go down and down until I nearly come down to the blast in the ordinary mode of working, but still it is a blast, and I applied it myself when working it in my own particular way, but it is the combination.' This reconciles the whole of that language with which I was so much pressed before, and have been again pressed in the argument of this case. The contest in Bovill v. Keyworth was what was the exact nature of the patent, and the patentee says my patent is a combination of exhaust and blast. In Bovill v. Keyworth, it was the artificial blast, and all the evidence went to the artificial blast.

Does that prevent the Court from holding, when it is used with the ordinary blast, that therefore the patent does not apply, and that if the plenum is not exhausted and no further draught created, and the same benefits produced exactly in the one case as in the other, that therefore you are to hold that is an application of his patent to that particular state of things? I say it does not. I am very glad to have the opportunity of having such authorities before me. I agree with the Master of the Rolls and Mr. Justice Willes, in thinking that the exclusion of the plenum and modification of the exhaust is not confined to the artificial blast, but is applicable to any blast wherever the plenum is created; and I hold, for the reasons I have already assigned, that a plenum is created by the working in the common ordinary mode of procedure.

"Now, after having made these observations, what is there new in this case before me? I will specify all the points which I think are new in the case, as contrasted with Bovill v. Crate. There is the point which Mr. James took on the specification, as applied to this construction of the patent, being an insufficient specification for the direction of an ordinary workman as to what it is that he is to do with reference to the construction of this particular patent before him; and, also (for you have a right to introduce that) what he is to avoid, for perhaps that is the strongest way of putting it for the defendant, when he is constructing machinery in order not to infringe the plaintiff's patent. Mr. Bramwell's evidence was directed more particularly to that branch of the case. That is one point. The next new point is the production of evidence of Debcaune's design. The next is the introduction of the working of Wren's Mill. I do not think, beyond that, there is anything new whatever in this case, though there are variations of evidence as to many matters which came in evidence before me on a former occasion. There is evidence as to the Isleworth Mills and the old story as to that; there is evidence again as to the Houghton Mills; there is evidence as to the Tradeston Mills of Messrs. Muir, and there is evidence before me of the French patents, with the patent of Cabanes, and some little attempt (a very feeble and slight attempt it is) to shew the mode by which Cabane's patent might be worked, as to which some gentleman says he went over to France a year or two ago and that he saw the thing being done. I believe that is the whole of what is new."

"Now, first as to the argument on the specification. What Mr. Bramwell says is this: Mr. Bramwell's evidence is an extremely ingenious argument against my former decision in many respects, and I give it that weight and respect which I must unfeignedly feel for his scientific ability and judgment, in reconsidering this case. As regards this particular part of the case on the specification he says, 'no workman looking at that description could possibly understand that he was infringing the patent unless he was applying the exhaustion of the plenum in the degree described to a case in which the artificial blast had been used and no other.' He said that would be the thing that every workman would suppose. Everybody would agree in that especially if he happened to read the former part of the patent of the plaintiff, and the disclaimed portion of it describing the three things; he must arrive at the conclusion that upon that and that alone he was infringing the patent. But that does not appear to me an argument which is sufficient. The first thing is—Is the specification sufficient to describe what the workman is to do? He is to exhaust a plenum if there is one, and he is to do no more. This is what in Bovill v. Keyworth Lord Campbell said the workman was to do; and Lord Campbell was of opinion, and I do not find anything Mr. Bramwell has said to the contrary of it, that a workman being told to exhaust the plenum and nothing more, would know what he had to do if it was with a blast introduced. We must assume upon that, that that is enough for the workman to know—the machinery is all known, and how you can adjust it by means of slides and otherwise. Therefore that can all be easily adjusted and the workman will know very well if there is an artificial blast. Then I would mention this particularly with reference to an argument which Mr. Little pressed me with, saying the plaintiff has described how you are to judge whether you have got the right degree of exhaustion: you are to put your candle there and when you find your candle stationary or nearly stationary then you are right, should it waver one way or another then you are wrong. Why did he not say all this in his patent? The argument would apply just as strongly to the artificial blast, and why did he not say all this? In the case of Bovill v. Keyworth, Lord Campbell thought—and I confess I think so too—that the thing was perfectly sufficiently described, at all events for that purpose, and that there was no necessity, the thing being well known, for telling any workman how such matters were to be adjusted. When Mr. Little tells me there is no evidence in this case on this point, I refer to Mr. Fothergill's evidence—it was hardly necessary, except *pro forma*, to have any evidence—Mr. Fothergill describes how that is to be done by the specification in the 5th paragraph of his affidavit. Then if that be so, the only difficulty that remains is this—the difficulty of the workman—supposing there is to be applied to the concern a different sort of plenum. The workman has nothing to do with that, he is to exhaust the plenum if he finds one. I have already held, for the reasons I have mentioned, that he does find one in the ordinary working of the stones. If he does find it he is to exhaust it—he cannot find any difficulty in doing it one way more than the other. Mr. Webster says he can measure what he is to pump in very easily, and he knows he is to pump out exactly as much. I apprehend the use of slides was well known in this part of the process; in almost all the drawings before me that is shewn. When a man wants to force in air or force it out he knows exactly what he has to do, and by means of slides he can do it, or by means of having a fan with the same amount of action for drawing out or for drawing in. You might just as fairly say to the patentee he ought to have told the workman to take a fan calculated to pump out so much as was pumped in, as to say he ought to have told you you were to get slides, or to get a candle and apply it to see that you had done what you ought to do. It appears to me that on that new ground of the specification, what is called a new construction of the patent—I do not hold it to be so—that that argument has really no application so as to make it incumbent on me to reconsider the case on the alleged new view which I am supposed to have taken of the effect of the patent.

"Now, then, as regards the case of Debeaune. I am quite prepared to take that case, because all I say upon the case of Debeaune will apply as much to Cabanes, but stronger to Cabanes, in this respect, that as regards Cabanes it is not a question of discovery, whether it was discovered to the public, but a question on the section of the patent law which goes to this, whether or not a man has a patent for the same thing abroad as he has here? Now the argument I am about to use with reference to Debcaune's design, applies more strongly to Cabanes' case than to his. With regard to Debeaune's it stands thus:—There it is, you have a series of millstones and a reservoir where the stive is collected. I take the liberty, in passing, to observe that I do not agree with Mr. Bramwell's view, in one part of his evidence, where he says the plaintiff describes the plenum as the stive and dust."

[Mr. Bramwell did not say that the plaintiff did give such a description of the plenum. The passage of Mr. Bramwell's affidavit of which the judge was thinking was this:—

"I say that in the specification under Cabanes' certificate of addition of 26th May, 1846, the exact invention which in my judgment and belief is described in the plaintiff's specification of 1849, as the second claim of invention therein mentioned is clearly shewn and described, for by such specification and drawings Cabanes shews in the clearest and most unmistakeable manner, that air is to be blown by a fan into the closed eye of the millstone, so as to force a plenum of air between the grinding surfaces of the stones, and that a second fan is to be used for the purpose of exhausting such plenum, which the patentee describes as the stive, the hot air or the evaporation produced in the interior of the millstone case. The patentee also describes that the stive or hot air being exhausted through the tube 'M,' passes through the fan, and is driven by the blades into the tube 'N,' which conducts it outside, or better, into a box arranged for this purpose, or finally into the rake chamber or meal collecting-room."]

The judgment continues:—

"The plaintiff's plenum, I apprehend, is the surplus air which is created by the indraught. Now, you have therefore in Debeaune's case, an apparatus which collects into a reservoir the heated air which would rise by its own levity, if I may use such an expression (it is occasioned, probably, from the pressure of the heavier air about it), in the reservoir, and the moisture is carried up with it, and he applies to that reservoir, and to the several stones, an apparatus of exhaustion. The passage I referred to in Mr. Bramwell's affidavit, is paragraph 13, in which he speaks of the exhaustion of such a plenum, 'which the patentee describes as the stive, the hot air, or the vapour produced in the interior of the millstone case.' That is not all. No doubt the pleuum contained all those things, but the plenum is not exactly the hot or dusty air; the plenum is the surplus produced by the indraught. Now, then, Debeaune tells you, you are to exhaust this; but Newton, in his patent, had used an exhaust for creating a draught, and he used it for that particular purpose. He had not used it for the special purpose of removing hot air, and dust, and the like. But what has the direction contained in Debeaune's process, or in Cabanes' process, to do with giving you the exact measure which Lord Campbell points out as being the important thing, and which seems to be the important thing in the plaintiff's discovery, where you are to use the exhaust; and where is the direction in Debeaune's, or Cabanes', that you are not to make such an exhaust as to create any draught? In Newton's case, it seems to have been a total failure. Gordon's blast, and the plaintiff's blast do not seem to have been total failures; but the thing is a total failure if you exhaust too much. I do not see a single direction in Debeaune's, or a single caution in Debeaune's diagram or description, nor do I in Cabanes' description or diagram find anything which gives you that limit, and tells you, in fact, that that is the essence of the discovery. As to Cabanes' case, the plaintiff makes a comment upon it in his affidavit. These matters are all more matters of comment than of evidence, but the plaintiff, turning his mind to Cabanes,' says here, as he said on the former occasion, 'Cabanes' whole process seems to me to be directed to what he calls acceleration, aud the acceleration is to make tbe thing go as fast as possible. He says, 'when you use both the blast and exhanst, you do it to work it as rapidly as possible, and in the most contiuuous way, to produce tbe blast;' there is no caution and no direction whatever given that you are to take care so to use your exhaust as to carry off the additional amount of air, and no more. As far as the model goes, there is certainly nothing whatever in the model which is brought into Court as exhibiting and shewing what Cabanes' was (it is a tolerably fair description of the diagram,) to shew that there was any notion in his mind of directing the tbing to be exactly measured in oue way or the other. The pipe for forcing the air in, was considerably larger than the pipe for tbe exhaustion process; and it does not appear to me tbat there is anything given you in the description to show that you are to measure the one by the other, and that his plan was to be like the plaintiff's plan, simply to exhaust that additional quantity which was poured in, and to do no more.

"That being so, both in Cabanes' case, and Debeaune's case, it really seems to me, neither of those cases come up to the invention claimed by plaintiff, and I am fortified in this conclusion, because Debeaune's invention remained a dead lettor; there is no evidence that any human being ever tried Debeaune's invention, or thought it worth a moment's attention. As to Cabanes' iuvention, nobody has said they ever tried it, but somebody gives evidence now, that it can be done, as I have no doubt it can, with all the improved knowledge which the plaintiff has given them, and which they have obtained since the year 1849, I have no doubt they could get an exhaust exactly like it, but what I am to look at is, whether there is anything in Cabanes' specification, which tells you how to do what the plaintiff does; Mr. Bramwell says, it tells how to do it much better than the plaintiff does it. Cabanes has not described that which Lord Chief Justice Campbell said was necessary. He has not described the fan or the tubes, he has not described them, notwitbstanding he bas produced these French drawing, executed with the extreme neatness and precision which the French draughtsmen (and the French logicians indeed) are so celebrated for, and I have no doubt he has put out everything which he thought we would want to know, and which he intended to lay before us. The question is, whether he has put out what is wanted, the extreme adjustment of the slides, and what you are to do to get it; not the mode of getting at the adjustment, because that is a simple enough matter, when you are told what the thing is, but what adjustment you are to make in order to arrive at the most efficient mode of working. That is just the thing which Cabanes does not seem to me to have told you. It might be said in Cabanes' case, no doubt, that having the thing you can easily make the adjustment, that would be met by Kay v. Marshall,—you can easily, having the larger measure, adjust yourself to the lower measure. That is a poiut of great importance. That point has been decided on the former occasion, and it appears to me correctly decided, and the case is removed also out of the difficulty the plaintiff might have been exposed to otherwise, if the point had not been determined upon the doctrine of Kay v. Marshall, on the want of information given by Debeaune and Cabanes.

"Now, then as to the other French patents:—

Mr. Grove.—"Will your Honour forgive me for interrupting you? Your Honour has not mentioned that Dr. King in his affidavit says that Debeaune's is substantially the same as Cartier's; it is not relied upon quite so much."

The Vice-Chancellor.—"That, of course, would bring the thing completely to that point, because Cabanes' is decidedly far more like than Cartier's. I do not think it necessary to go through Cartier's, I went through all the patents on the former occasion, and I am content to rest it there; I find nothing there pointed ont, which indicates that the exact point you are to achieve is that which has been achieved by the plaintiff's happy idea, by telling you how it is to be carried into effect."

We omit his Honour's comments upon evidence given as to Wren's Mill.

(*To be continued.*)

THE THAMES AT BARKING.

The following are Mr. Rawlinson's conclusions as to the state of the Thames at Barking:—"That the allegations in the memorial have only been partially proven. That the memorialists are not in a position to establish deterioration of health to emanations from the metropolitan main sewerage outfall works, as the town of Barking is without local governing powers, is un-sewered, contains many cesspools, a sewage-tainted subsoil, and has a defective water supply. That the River Thames is polluted by the metropolitan sewage, and receives such road and street detritus as the aforesaid sewage contains. That the main channel of the Thames has not been reduced in depth of water by such detritus. That Barking Creek has not been closed to vessels of 250 tons burden. That fish have been destroyed in the creek, but most probably by chymical refuse. That an accumulation of mud has taken place, both on the shore of the Thames and at the mouth of Barking Creek, but from what special cause has not been proven. That the Metropolitan Board of Works, in their annual reports, recognise their obligation to purify the Thames, and to effect this purpose have negotiated with second parties for the utilisation of the northern sewage by irrigation. That the Board, throughout their transaction for the utilisation of sewage, have stipulated for pecuniary relief to the metropolitan ratepayers. That the Metropolitan Board have objected to the admission of sewage into the Thames from towns situate above London, and therefore inferentially justify the objections to river pollution below London. That deodorisation and disinfection of the metropolitan sewage by chemicals would be very costly to the ratepayers, and in the results imperfect. That river pollution by town sewage in the case of the Thames, may be prevented." On the sanitary state of Barking Mr. Rawlinson says:—"The town of Barking has no local government. There is one drain which opens into the basin at the town quay, and any foul matter or sediment passed through this drain pollutes the water of the small basin bounded by the town quay. Barges also bring up London muck, which is loaded into waggons and carts for removal into the country, and the nuisance so caused is at times very offensive. The town of Barking is not sewered, and therefore the houses are not properly drained. There are numerous cesspools, the subsoil around which has become sodden with putrid sewage, and, as a consequence, the cesspools get full to the surface. One witness stated that the moment the house door was opened the stench of the cesspool was perceptible. There is no supply of water other than from pumps, wells, and water-carts. Those who have neither pump nor well (and this is the case with the greatest number of the inhabitants) have to purchase the water used by buckets or cans full. The result is that the sanitary destitution of the inhabitants is as bad as it can be, and in the event of any epidemic or contagious disease breaking out, all experience teaches that a population so situated will suffer in excess." Mr. Crowe, in his evidence, stated of Barking—"The town is governed by nobody, and consequently there is nothing done. The roads are allowed to get out of order, and no footpaths are made."

PROPOSED NEW RAILWAYS AND TRAMWAYS.

Plans, sections, &c., of the following railways and tramways have been deposited in the Private Bill Office for Bills in the next Session of Parliament:—

Birmingham Canal Navigation, Birmingham Street Tramways, Blackpool and Lytham Railway, Birmingham Tramways, Bristol Port and Channel Dock, Bristol and North Somersetshire Railway, Birmingham and Staffordshire Tramways, Belfast Central Railway, Barnstaple and Ilfracombe Railway, Bury St. Edmund's and Thetford Railway.

Chesterfield and Brampton Railway, Clyde Navigation, Cobham Railway, Continental Communication, Caledonian Railway (Tay Ferries and Land at Dundee), Caledonian (additional powers).

Dublin, Wicklow, and Wexford Railway. D'Olier-street, Dublin, Terminus Railway; Dublin and Suburban Tramways and Railways, Dudley, Oldbury, and Birmingham High Level Railway.

Ellesmere and Glyn Valley Railway, Ely and Bury St. Edmund's Railway, East and West Metropolitan Junction and Mansion House Railway; Edinburgh, Loanhead, Roslin, and Penicuick Railway.

Furness Railway, Fulham, Hammersmith, and City Railway.

Great Eastern (Metropolitan Railways) Great Northern and Western of Ireland (Westport Quay line), Glasgow Street Tramways, Gloucestershire and Berkeley Canal (new entrance and dock), Glasgow Tramways.

Hereford, Hay, and Brecon Railway, Hounslow and North London Railway.

International communication, Islington Railway.

Lancashire and Yorkshire Railway, Leeds Street Tramways, London and North-Western Railway (additional powers), London, Brighton, and South Coast Railway, (abandonment of Surrey and Sussex line), Leeds Tramways, London Street Tramways, Liverpool Tramways, Liverpool Street Tramways.

Margate Pier Extension, Manchester, Salford, and District Tramways (No. 1), Manchester, Salford, and District Tramways (No. 2), Midland Counties and South Wales Railway, Midland (Wirksworth and Rowsley) Railway, Midland (additional powers) Railway, Manchester Street Tramways, Manchester Tramways, Metropolitan District Railway, Metropolitan and St. John's-wood Railway, Metropolitan Street Tramways.

North London Tramways, Newport Pagnell Railway, Newport Railway, North-Eastern (Hawe and Melmerley, &c.) Railway, North British (Tay Bridge) Railway, North British (general powers), North Metropolitan Tramways, North Western and Charing-cross (deviations).

Oswestry Llangynog Railway.

Pembroke and Tenby (extension to Pembroke Dock,) Penicuick Railway, Preston Station (enlargement, &c.) Portsmouth Street Tramways, Plymouth, Stonehouse, and Devonport Tramways, Pimlico, Peckham, and Greenwich Street Tramways, Pimlico, Peckham, and Greenwich Extension.

Ryde Pier Extension Railway, Ryde Station, Redhill, Bletchingly, and Godstone Railway.

Severn Junction Railway, Severn and Wye Railway and Canal, Southwark and City Subway (under the Thames), Severn Tunnel Railway, Sevenoaks, Maidstone, and Tunbridge Railway, South-Eastern Railway (deviation, Greenwich to Woolwich), Surbiton, Cobham, and Ripley Railway, Sutherland Railway Extension.

Wallasey Tramways, Worcester Railways and Tramways, Wolverhampton and Walsall Railway.

THE SOUTHERN EMBANKMENT.

Hitherto metropolitan improvements have been chiefly for the benefit of those who live on the north side of the river. But a work of much importance to South-west London—the Southern Embankment of the Thames between Westminster-bridge and Vauxhall—was thrown open for general traffic on the 24th of November. In one respect the Surrey side has been more fortunate than Middlesex. People have not been tantalized by seeing the roadway all but completed, and then torn up for the inevitable railway; and thus the southern carriage road, though begun much later, has been opened while that on the left bank of the river still remains a chaos, with railway contractors cutting into it and tunnelling under it from end to end.

The history of the new Embankment is soon told. When in 1862 Parliament authorised the Metropolitan Board of Works to embank the Thames from Westminster-bridge to the eastern boundary of the Temple, Lambeth raised up its voice and said that a similar work was still more necessary there. The names of Lambeth, Upper and Lower Marsh, still retained by streets at some distance from the river, show that the Thames of old was sometimes a very unpleasant neighbour. At high tides, in fact, the low-lying district hereabouts was flooded, to the injury both of property and of health. The inhabitants had, therefore, a strong claim to an embankment which would shut out the tidal water as well as open up a new, though not a very important, thoroughfare; and in 1863 the Metropolitan Board obtained fresh powers to embank the Thames from Gunhouse-alley, near the London Gas Works, to Westminster-bridge, and make a public road and footway. The coffer-dam was not, however, commenced till the autumn of 1865, and on the 28th of July, 1866, Sir William Tite, M.P., laid the foundation-stone of the new works, in the presence of Lord J. Manners, then First Commissioner of Works, the Lord Mayor, Sir J. Thwaites, and the members of the Metropolitan Board, and several members of the House of Commons. By that time it had been arranged that the new St. Thomas's Hospital should be constructed on the site on which it is now rising, and the two works were carried on with something like harmony. Six acres of foreshore were won from the river near Westminster-bridge for the purposes of the hospital; on the other hand, above Lambeth-bridge, two acres were surrendered to the river, which was thus widened where increased width was necessary, and made narrower lower down at a point where the tidal area was sufficiently great even after this encroachment. In May of last year the flagged footway, some 20ft. wide, between Westminster and Lambeth bridges, was opened for use, and on the 24th November both carriage-way and footpath were handed over for traffic.

The footpath skirts the Embankment, the wall of which is 4ft. high above the level of high water. Thus there is a terrace 20ft. wide, which is approached from Westminster-bridge by a flight of stone steps, and which nearly corresponds with the river terrace of the Houses of Parliament, just opposite; and above this is a second terrace forming the platform of the new hospital. The carriage road and the footpath at this point are separated by the hospital, the road commencing at Stangate, the ancient stone way or approach to the Archbishop's Palace. Stangate, which used to be a crooked and narrow way that could hardly, except by courtesy, be called a thoroughfare, is now improved into a straight road 60ft. wide.

The new road, which skirts the archi-episcopal grounds, joins the footpath in front of the palace, and thence continues along the Embankment towards Vauxhall. The new Embankment is a great ornament to the river; and the new Hospital, with the venerable towers of Lambeth, will form a background hardly less striking than the opposite Palace of Westminster. The total length of the river wall is 4,300ft. In elevation it resembles that of the Middlesex Embankment. There is a moulded parapet and plinth, and at intervals of 60ft. plain granite pedestals, ornamented with lions' heads in bronze, and hereafter to be topped with gas standards. On account of the shallow foreshore, no recesses for steamboat landing-places have been constructed, as in the Northern Embankment, but an improved approach to the Lambeth pier will shortly be made, and will be somewhat more ornamental than the present landing-stage. Above Lambeth-bridge, at the pottery works of Messrs. Doulton and Messrs. Stiff, docks have been constructed on the land side of the Embankment, and the entrances to these pass under the roadway without interfering with its level. These detract somewhat from the appearance of the Embankment, and so also do the openings made further up the river to accommodate the traffic formerly using the White Hart Draw Dock. As Stangate, Bishop's-walk, Palace New-road, and Vauxhall-row have been absorbed in the new road, there is now between Westminster and Vauxhall bridges a carriage way and footpaths about 60ft. wide, which form a short and good communication between the Borough, by way of Southwark-street, Stamford-street, and York-road, and the suburbs of Battersea, Wandsworth, Clapham, and Kennington. The carriage way is for the most part paved with Aberdeen granite cubes laid on a bed of lias lime concrete, and an improved approach and gradient has been made to Lambeth-bridge. The total cost of the great work has been not far short of a million of money. But St. Thomas's Hospital pays £105,000 for its site, and the Metropolitan Board has been recouped in other ways to the extent of some £30,000, so that the net cost is reckoned approximately at £858,000. The bulk of this has been paid for compensations, which have amounted to £713,000, the actual cost of the works being about £280,000.

THE VOYAGE OF THE FLOATING DOCK TO BERMUDA.

An interesting account of this voyage has been written by "One of those on Board," from which we find that, contrary to the forebodings of many nautical men, this gigantic structure arrived perfectly safe, and apparently without any difficulty. It will be remembered that it was built by Messrs. Campbell, Johnstone, and Co., and that a full account of its construction appeared in The Artizan; having been begun in August, 186[illegible], and finished in May, 18[illegible]9, at a cost of close upon a quarter of a million. She was fitted with a gigantic rudder, and two light wooden bridges were thrown across her for purposes of navigation; lighthouses, semaphores for signalling to her consorts by day, and flashing lanterns for night work were supplied to her; she was also provided with steam whistles and guns in case of fog, and at each corner was fixed a lightning conductor. Her crew consisted of 82 hands, under a staff commander and other officers, and were quartered in several of the upper watertight compartments, which were fitted as cabins, &c. As these had no ports, their ventilation was only such as the hatchways afforded, and in hot weather the "'tween decks" of the dock were almost unbearable. Her high sides were decked with wood, and afforded fair walking room, but by descending 53 feet of ladders her floor could be reached, and its clear space of 110 yards in length was a famous exercise ground.

The Bermuda was sent to sea without her caissons, which weigh about 400 tons. These, having ~~been made and~~ fitted in England, were conveyed in pieces to Bermuda, and there riveted together by a body of workmen sent out for that purpose by the contractor. Even without them the Dock weighed 8,200 tons, and although when the wind was fair a sort of sail or curtain was set between her sides, neither this nor her ponderous rudder was found to be of much assistance. She had to trust entirely, both for towing and steering, to the engines of the men-of-war appointed to convey her to her destination. The vessels selected carried, perhaps, the most powerful machinery afloat, and, by the skilful application of competent strength, the Bermuda was moved through the water at an average speed of about five knots an hour. On the 23rd of June last she slipped her moorings in the Medway, and, being taken in tow by six tugs, proceeded to the rendezvous at the Nore, where the ironclads Northumberland and Agincourt were in waiting to pick her up. The *Terrible*, whose paddle-wheels have been doing good service for the last 25 years, steamed astern and in tow of the dock, for the double purpose of steering and of acting as a check upon her should she prove unruly. The work of attaching the dock to the *Northumberland* was quickly accomplished. She was brought under the ironclad's stern; the immense hawsers, 620 feet in length and 26 inches in circumference, were at once passed between the vessels, and the squadron started down the Channel. These hawsers were secured to the riding-bits in the cut-water deck, with which the dock had been fitted, and which formed part of the original design for rendering her navigable. This deck projected 24ft., and was sloped away on the under side, so at to offer the least possible resistance to her progress; the after end of the dock was rounded off in a similar manner. The squadron made its way slowly down the Channel, the *Agincourt* and *Northumberland*, harnessed in tandem fashion, in front of the Bermuda, and the *Terrible* partly steaming and partly towing astern to keep the huge mass from yawing. The *Buzzard* and *Medusa*, soon afterwards relieved by the *Helicon* and *Lapwing*, took up their positions on either side, acting as a sort of police to warn off any vessels that might approach dangerously near to this strange ocean procession. The decks of her high sides were at about the elevation of the mizentop of the *Agincourt*, and outside the house which served as the captain's cabin was a regular flower garden, in which sweet peas, mignonette, and other common flowers flourished, giving to the place, as the writer of the journal observes, more the appearance of an Australian shanty in the bush than of anything appertaining to shipboard.

The hydrographer to the Admiralty had laid down a track, which was carefully adhered to by the squadron; it was based, as was the date of sailing, on the most careful consideration of probable wind and weather, and the result showed how soundly statistical knowledge of this sort may be applied. During the whole of her voyage, which lasted 36 days, nothing but the finest weather was met with; good luck, as well as good management, contributed to a prosperous conclusion, and the Bermuda was towed into Grassy Bay, off Ireland Island, on Thursday, the 29th of July, and rode at anchor opposite the camber in which her life is to be passed. Since leaving the Medway there had been no accident to life or limb, although the clearing of the tackle, &c., often involved very dangerous service. The vessels towing her had been managed with a skill and delicacy only appreciable by those who know how much may depend in the crisis of an undertaking of this sort upon a few strokes of the wheel or turns of the screw. The careful selection and special qualifications of the officers is evident from the fact that in passing through the "Narrows" of Bermuda the dock was committed to the charge of two gunboats stationed at the island which were so badly handled that perhaps the whole undertaking would have been frustrated by some catastrophe had not officers from the *Warrior* been sent to take command of them, after which they worked perfectly. The last few miles were the most anxious of the whole voyage, and the currents of the "Narrows," the tortuous and shallow channels involved great risk; the ironclads drew too much water to be used here, and the Bermuda evinced at one time a disposition to start on her own account for Halifax, taking the *Terrible*, which was doing her best to persuade the dock to face the "Narrows" in tow. However, after a day's expenditure of tackle as has rarely been equalled in naval annals, the monster was coaxed into submission, and passed into the harbour all safe.

The only place touched at in the voyage was Porto Santo, in the Madeira group, where the *Agincourt* and *Northumberland* gave place to the *Warrior* and *Black Prince*. The highest speed ever attained was 6½ knots; but this involved a great consumption of coal, the husbanding of which was one of the chief necessities of the expedition. The senior officer was most unremitting in the careful performance of his duty; day and night, all through the voyage, flags, semaphores, and lanterns were at work, and the signalmen of the squadron had little rest; every *contretemps* was foreseen, and defeated by some new expedient, and the whole conduct of the expedition was without a single mistake. It is not often that a first venture so novel in itself, and involving such great risks, has had such perfect success.

RAILWAY BENEVOLENT INSTITUTION.

A fund which deserves the notice and encouragement of all who travel by railways—that is to say, the whole nation—is collected about this time at the many railway stations throughout England. The object is to provide some compensation for every railway servant who meets with an accident in the discharge of his duty: for this purpose the men are called upon to subscribe one shilling each. The public may not unfairly be asked to help the good work, by sending contributions to the offices of the institution, 123, Seymour-street, Euston-square. In the year now ended 18,360 employés of different railway companies subscribed to the fund and about 500 have experienced its benefits. It will be seen that self-help has not been wanting; but at the same time aid from without will be very acceptable, and will hardly be denied by habitual travellers.

Obituary.

THE LATE GEORGE SMITH, ESQ., C.E., BELFAST HARBOUR ENGINEER.

Mr. George Smith, C.E., was for twenty-four years, the resident engineer of the Belfast Harbour, and during that long period of active unobtrusive service did an extent of work which only those who are intimately acquainted with the past and the present state of Belfast Harbour, can adequately apppeciate. The late Mr. Smith was an Englishman, and was appointed Harbour Engineer in 1839, on the recommendation of Messrs. Walker and Burgess, the eminent engineers, who at that time designed some improvements in the harbour. Mr. Smith was previously engineer in the Leeds and Selby Railway. It was under his superintendence that the new cut at the Queen's Island and the channel between the Twin Islands were formed, the contractor being the late Mr. Dargan. The Queen's Quay, Clarendon Dock, and all the timber wharfs on the Down and Antrim sides of the river were also constructed under his superintendence. The filling up of the old docks—Limekiln Dock running into Waring-street, Ritchie's Dock up to Great George's-street, and Town Dock up High-street to where the Albert Memorial now stands, and all the extensive improvements in connexion therewith were executed by him. He was the architect of the new Harbour Office; he designed the lighthouse on Holywood Bank; it was under his superintendence that the Patent Slip was constructed; he carried out all the reclamation improvements on the County Down side of the river; and the extensive ranges of sheds along the quays were all planned and executed by Mr. Smith. Indeed, all the great improvements in the Harbour of Belfast completed during the past thirty years, were carried out under his management. If the late Mr. Smith had at any time been asked to show the extent of what he had done for Belfast Harbour, he might have taken the interrogator to the tower of the Harbour Office and said with perfect truth, *Si monumentum quæris, circumspice.* From the summit of that public building, itself a model of good architecture and economy in construction, the eye would range over long lines of quays and docks, bridges, steamers passing at all times of the tide in and out of port, by a straight channel instead of the former tortuous course, a harbour well buoyed and beaconed, green trees and grass where foul weed-banks once spread—all made by Mr. Smith. In fact, the history of Belfast Harbour improvements up to a very recent period was written by Mr. Smith in the extensive works of practical utility which he executed. The deceased gentleman was unobtrusive, and kept clear of all public matters, devoting his acknowledged professional abilities and his unwearied exertions to the duty which he had to discharge, and in which he spent his strength and his life. From failing health he became unable to continue the more active duties of his office, and in 1863 he was appointed Consulting Engineer to the Harbour Board. For some time past increasing infirmities and age proved too much for him, and on the 3rd ult. he expired at the age of 77, leaving behind him the esteem and respect of all who knew him, and the reputation of as faithful, diligent, and capable a public officer as ever filled an important post in Belfast.

REVIEWS AND NOTICES OF NEW BOOKS.

Railway Diagram of London and its Suburbs. By Mr. Airey, of the Railway Clearing House.

This diagram is well defined and clear. The omission of the streets tends much to make it plain. All the various properties, stations, junctions, distances (in miles and chains) running powers and working arrangements are accurately laid down. We can commend the publication as trustworthy and useful.

We have on previous occasions noticed similar admirable productions of Mr. Airey, and we have had several opportunities of proving his correctness of the plans of complicated railway junctions.

The Timber Trades' Price Book. By William Richardson. London: Longman, Green, and Co.

A useful little Pocket Ready Reckoner for ascertaining the value of timber of all dimensions. It is all in tabular form, and from its simplicity, scarcely needs the few explanatory examples given of each series of tables.

CORRESPONDENCE.

We cannot hold ourselves responsible for the opinions of our Correspondents.

THE SUEZ CANAL.

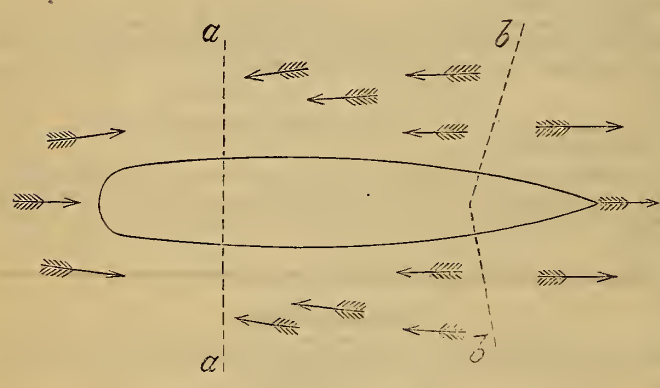
To the Editor of The Artizan.

Aden, *4th December*, 1869.
H.M.S. Nile.

Sir,—I have been particularly fortunate in having had it in my power to inspect the Suez Canal after all the crowd of visitors had passed, so that I was not hurried, and by the kindness of the French Engineers, who were most ready to give full information on any point I desired. I have been able I trust to form a pretty correct idea of the actual state of matters.

With regard to the canal itself, I think all concerned have cause to feel satisfied with the result, and at present ships drawing from 16 to 17 feet of water may navigate the Suez Canal from end to end without difficulty or delay, provided they be properly steered. One point the French authorities should—and I have no doubt, will—look to, is to have the ships passing through the canal steered by a wheel placed on the bridge, or on some point on the fore part of the ship, for it is necessary that the man who steers should be able to see for himself how the deep channel is marked out. Had this been done, I believe most ships could have passed through without hardly ever touching the banks. The ship I came down the canal in, was about 300 feet in length, and drew nearly 16 feet, and had this steamer been steered by a wheel on the bridge instead of at the stern, I do not belive we should ever have touched. Not that we were much delayed, as we never stuck longer than a quarter of an hour on any occasion, if so much, and that only on one occasion. Our speed through the canal itself averaged about five miles an hour, while through the Bitter Lakes we averaged twelve miles an hour, and it is to this question I would like to say few words, as I believe that by careful observations on the action of the several waves formed by the ships of various dimensions and lines passing at different velocities through the canal where the sections differ, would lead to most interesting discoveries as to the motion of ships through the water. My observations of course were very general, but I may say that the height of the wave very much depended on the breadth and section of the canal. Where it was broad and deep there was often hardly any perceptible wave whatever; where the channel was more contracted, yet still deep at the sides, the wave had more the nature of one of undulation than that of translation, but where the depth at the point where the slopes reached the water was only a foot or so, the wave of translation became considerable, rising to a height of from eighteen inches to two feet, and there was considerable washing away of the slopes, but nothing serious; in fact not so great as I was prepared to expect, with a velocity of five miles an hour. I should therefore say, that at present a speed of five miles an hour with the canal of its present breadth was safe. With an increased section, however, the velocity may I think, be raised to six miles an hour, but I do not think this speed should be exceeded by large sea-going steamers; so for the present such vessels must rest content with passing through the canal in two days, one day from Port Said to the Timsah Lake, anchoring there all night, and the next day passing on to Suez.

What struck me as most remarkable regarding this wave question was that the several waves, or rather currents, may be divided into three in quite opposite directions. The ship I came down the canal was a screw steamer (I say down from the north to the south) and was, as before mentioned, about 300 feet in length, with fine lines, and drew very nearly 16 feet of water. ividing the ship into four equal parts, thus:—



All in front of *b*, *b* was pushed forward in the direction the ship was passing, but with no apparent violent action. In the space between *b*, *b* and *a*, *a* the stream was very strong, increasing in velocity as *a*, *a* was approached, making in towards the "counter" of the ship, and beyond *a*, *a* the stream rushed in in the direction shown by the arrow, near the stern, the action on *a*, *a* depending on the depth along the canal bank.

These appear to me very interesting facts, and some of the readers of The Artizan may be able to further investigate this question under more favourable circumstances.

I remain, Sir, your obedient servant,

T. Login, C.E., F.R.S.E.

The East London Railway.—The first section of this company's line was formally opened on the 6th ult. from New Cross to the north end of the Thames Tunnel at Wapping, about three miles in length. The line was in excellent condition, and the train consisted of new carriages, affording ample accommodation for third-class passengers. The stations at New Cross, Deptford-road, Rotherhithe, and Wapping are convenient and well constructed. The line is to be worked by the London Brighton, and South Coast Railway Company. There are to be 23 trains each way on week days, and 20 trains each way on Sundays. The works remaining to be completed on the Surrey side are the connecting line with the South Eastern Railway, and the junction with the up main line of the Brighton Railway; and on the Middlesex side, the continuation of the line from Wapping, under the London Docks to Brick-lane, the point of junction with the Great Eastern Railway for passenger traffic, and the junction with that line near Bethnal-green for the goods and mineral traffic, together making about 3¼ miles of line to construct. The expenditure to the present time has been, on the south side of the river, including the Thames Tunnel, £976,474, and on the north side of the river, £381,516, together £1,357,990.

NOTES AND NOVELTIES.

MISCELLANEOUS.

Aloe Fibre in Mauritius.—Another article of colonial production which has for years past, from time to time, attracted public notice, seems now to have some chance of assuming, ere very long, an important place in the exports of Mauritius. This is aloe fibre, which is now being extracted for exportation by several persons; and in Bourbon, where sugar planting has ever been less successful than Mauritius, a still larger amount of attention has been bestowed on this fibre; and machines have been erected in several places, capable of beating out 1,000lb. of it per diem. The aloe (that known as the Yucca) grows wild in immense numbers on the mountains of these islands; and, like all species of aloes, it is very hardy, being little affected by dry seasons. The fibre is worth £25 to £30 per ton in Europe, and it is believed that it will gradually become an article of considerable importance in the colony.

United States' Patents.—In the year ending the 30th of September, 1869, no less than 19,360 applications were made for patents in the United States, including re-issues and designs; and 13,762 patents were issued. The fees received at the Patent-office were 213,926dols., in excess of the expenditure. The office publishes a weekly list of claims which is supplied to subscribers at 5dols., per annum.

It is said that a Russian line of steamers from the Black Sea to Bombay, *via* the Suez Canal, is about to be established, with contracts already made by one house at Moscow to ship 4,000 bales of cotton per week.

SHIPBUILDING.

Shipbuilding on the Clyde.—The Clyde shipbuilding yards have set afloat no fewer than eighteen vessels during the month of November. Nine of the launches were at Glasgow, four at Greenock, three at Dumbarton, one at Port Glasgow, and one at Rothesay. Nine were steamers, and nine were sailing ships, and, as usual, the large proportion were iron vessels. The total tonnage represented was close on 20,000. The largest of the eighteen is the *Scandinavian*, an iron steamer of about 3,000 tons, built by Messrs. R. Steele and Co., Greenock, for the Allan Montreal Line. Next in size is the *Elbe*, a screw steamer of 2,657 tons, built by Mr. John Elder, Govan, for the West India Mail service. The *Apis*, an iron screw steamer of 1,200 tons, built by Messrs. Denny, Dumbarton, for the Austrian Lloyd's service; the *Afrique*, a screw steamer of 1,800 tons, built by Messrs. Napier and Sons, Govan, for the Marseilles and Alexandria trade; and the *Shang Tung*, a screw steamer of 1,500 tons, built by Messrs. A. and J. Inglis, Glasgow, for the Shanghai Steam Navigation Company, stand next on the list.

TELEGRAPHIC ENGINEERING.

Captain R. R. Oldfield, of the Royal Navy, an experienced officer, has been granted leave by the Admiralty, and has proceeded on behalf of the Telegraphic Construction and Maintenance Company to Siam and the Malay Peninsula for the purpose of exploring certain routes by which that company proposes to establish a telegraphic communication from Burmah, the Tenasserim Provinces, and Siam with Penang, so as to throw the traffic upon the British Extension Company's cable, which will be laid this year between the Straits of Malacca and Ceylon.

Telegraph Concessions.—The Russian Government has granted a concession of thirty years to M. Titgen, Councillor of State to the King of Denmark, M. Erickson, a merchant, and M. Pallisen, consul-general for that country at St. Petersburgh, for the establishment of submarine telegraphic lines between Asiatic Russia and Osaka, Yokohama, or Nangasaki, in Japan; and Shanghae, Fou-djaon, and Hong-Kong, in China. The company thus formed will ask for the authorisation of the Chinese and Japanese Governments, and the Russian executive will lend its good offices in the matter. The concessionaires bind themselves to attach this system of telegraphy to a station and telegraphic line of the state in Russia in Asia.

The cables of the West India and Panama Telegraph Company, to connect Cuba, Jamaica, and Porto Rico, have been completed at the Silvertown Works, and the whole of the line will be shipped by March 15th.

LAUNCHES

A new steamship, the *Alnwick Castle*, built by Messrs. C. Mitchell and Co., Low Walker, on the Tyne, for the Northumberland Steam Shipping Company, was launched on the 4th ult. She is intended for the Indian trade, *via* the Suez Canal, and she has been specially constructed for the purpose. Her rig will be that of a four-masted schooner, and she will have engines of 600-horse power. If the Suez Canal proves a safe water-way for steamers to proceed from the Mediterranean to the Red Sea, it is likely that good deal of new iron steam tonnage building for Tyne shipowners will be employed in the East India trade by this route.

On the 19th ult., there was launched from the shipbuilding yard of the late Mr. John Elder, at Fairfield Govan, an iron paddle steam ship, of 1,350 tons, B.M., and 300 horse power nominal. As the vessel left the ways she was gracefully christened the *Arequipa* by Miss Jay. The *Arequipa* has been built to the order of the Pacific Steam Navigation Company, Liverpool, and is intended for their mail and passenger service on the west coast of South America. This firm has also on hand two large ships for the same company.

RAILWAYS.

Influence of Railroads upon Weather.—The opinion seems to be gaining strength that the Pacific Railroad is working a great change in the climate of the plains. Instead of continuous droughts all along the railroad rain now falls in refreshing abundance. This result has been remarked upon in other sections of the West. In Central Ohio, for example, it is said, the climate has been completely revolutionized since iron rails have formed a network all over that region. Instead of the destructive droughts formerly suffered there, for some four or five years there has been rain in abundance—even more than enough to satisfy all the wants of farmers. This change is thought to be the result of an equilibrium produced in the electrical currents, which has brought about a more uniform dispensation of the rain. It is a fact within the observation of all who remember anti-railroad times that we have now few or no such thunder-storms as we formerly had in New England. The iron rails which touch and cross each other in every direction serve as conductors and equalisers of the electric currents, and so prevent the terrible explosions which used to terrify us in former years. The telegraphic wires which accompany the iron rails everywhere also act an important part in diffusing electricity equally through the atmosphere, thus preventing the occurrence of severe thunder-storms.—*Boston Traveller*.

The great Louisville railway bridge across the Ohio is now ready for use. It is supported by 25 massive piers, the length of the longest span being 320ft., while the entire length of the bridge lacks but 80ft. of a mile. The cost will exceed a million and a half dols.

The demand for iron for Indian railways appears to be again increasing. the exports of railway iron from the United Kingdom to British India to October 31st this year having been 76,200 tons, as compared with 61,333 tons in the corresponding period of 1868, and 140,606 tons in the corresponding period of 1867.

ACCIDENTS.

Steamboat Explosion.—On the 1st ult., a sad accident occurred on the Clyde, between Innellan and Dunoon, by the blowing up of the boiler of a screw steam-lighter, causing the deaths of the whole crew, supposed to number five men. The steamer was seen passing Innellan, and when about a mile and a half beyond it the boat seemed as if lifted clean out of the water, after which she went down. A large quantity of wreck rose to the surface shortly after, and gave evidence that the lighter had gone to pieces. The bodies of none of the men were recovered up to the time the last steamer left, but three caps were picked up floating on the water. A number of small boats put out from the shore to search for the bodies, but these only brought ashore pieces of the wreck.

Fall of a Large Railway Shed.—On the 6th ult., the passenger shed of the new Caledonian Railway station at the Lothian-road, fell with a loud noise. The shed had been completed with the exception of the work to be done by the slaters on the roof, and during the day about 100 men had been employed upon it. When the accident occurred all the workmen had left with the exception of four, who were in one end of the building; but fortunately they escaped uninjured. A horse was caught by some of the beams, but was ultimately rescued without sustaining much damage. The building, which was constructed chiefly of wood, was fully 400ft. in length and between 80ft. and 90ft. in breadth.

A Gasometer Blown Down.—An extraordinary accident occurred on the 13th ult., upon the premises of the Cambridge University and Town Gasworks. The wind, which had been very strong all day, had then increased in violence to such a degree that the largest gasometer attached to the works was completely capsized, and many thousands of cubic feet of gas escaped instantaneously. Although there was no light of any kind within 30yds. of the gasometer, the nearest light instantly illumined the gas, and an immense flame of fire rose to the heavens, lighting up the sky in the most vivid manner. The utmost alarm was felt in Cambridge when this became apparent, but happily no explosion occurred. The flame caused a fire on the premises, and it was at one time feared that it would reach the remaining gasometers. This, however, was fortunately prevented by the exertions of a large number of the inhabitants, who went up from Cambridge to Barnwell, where the works are situated, directly the illumination commenced. The new gasometer which was blown over had been only recently erected at a cost of £6,000, and a heavy loss will fall upon the company in consequence of the accident.

Another Gasometer Blown Down.—The Gloucester Gasworks were on the 15th ult. a scene of an accident almost equally serious with that which happened at Cambridge. A large gasometer, capable of holding 240,000ft. of gas, has recently been erected at the works at a cost of nearly £4,000; and there are two other gasometers, holding together about 130,000ft. The works are situated on the Severn Quay. Shortly after one in the morning one of the chains supporting the largest gasometer was broken by the violence of the wind, and the breaking of a second chain just after caused the vessel to rapidly descend. While it was descending one of the large iron pulleys fell over and broke a hole in the crown. The gas escaped rapidly through the rent, and, despite the efforts of the workmen, the 70,000ft. the gasometer had contained were soon exhausted. There was a light near, but no explosion occurred.

DOCKS, HARBOURS, BRIDGES

A Huge Bridge.—The iron bridge at St. Louis, connecting the Illinois and Missouri shores of the Mississippi river, is reported to have been commenced, and four hundred and thirty men, with all the modern steam appliances for excavating earth and moving heavy stones and timbers, are now at work. The bridge structure is to be composed of three wrought and cast iron arches, one of 515ft. in length, the other two 497ft. each. The lower part of the bridge is intended for the passage of railway trains, the upper for ordinary traffic.

The Peninsular and Oriental Company have just concluded a contract with Messrs. Caird and Co., of Greenock, for the construction of two screw steamers of 3,400 tons and 600 horse power nominal, the engines to be upon the compound or high and low pressure principle. Messrs. Caird and Co. have already nearly completed one steamer of the same tonnage and character for the service of this company, while similar vessels, the *Deccan* and *Hindostan*, built by Messrs. Denny and Co., of Dumbarton, and Messrs. Day, of Southampton, have recently been despatched to India. These additions to the company's fleet represent 17,000 tons and 3,000 nominal horse power.

Indications accumulate that the success of the Suez Canal will rapidly bring about a solution of the question of the practicability of a ship canal to unite the Atlantic and Pacific. The Nicaragua route seems at present to attract the most attention. As to the raising of the necessary means, which have been estimated as high as 20 millions sterling, much will depend upon the pecuniary results of the Suez Canal. If these should be satisfactory the affair may perhaps come to be entertained even as a private enterprise. Otherwise State aid may be invoked. In one form or the other there seems little doubt that the American people will force the accomplishment of the design.

MINES, METALLURGY, &c.

Iron Works in Russia.—The establishment is proposed in the Government of Catherinoslav (Russia) of iron works, to be capable of producing 500,000 pounds of rails annually; Russia chafes under the large imports of rails which she has now to make from other countries.

The report of the Scinde Railway Company for the half year ending 30th June last, has been issued. The net revenue of the Scinde Railway for that period has been £14,808 1s. 6d., against £19'463 15s. 10d, in the corresponding period of last year. The net revenue of the Indus Steam Flotilla was £11,565 18s. 7d. against £26,904 1s, 8d. in the corresponding half of 1868: that of the Punjaub Railway was £4,672 17s. 3d. against £15,768 12s. 5d.; and that of the Delhi Railway was £20,621 11s. 6d., against £3,958 2s. 1d. With respect to the last-named line the directors state that since the previous report the mileage of open line has been increased from 174 to 270 miles; the section from Umballah to Loodhiana, 70 miles in length, having been opened on October 1st, and that from the Beas to Jullundur, 26 miles in length, on the 15th November last. The section from Jullundur to Phillour, on the right bank of the Sutlej, will, it is expected, be ready by March next, when the entire railway, with the exception of the bridge across the Sutlej will be completed throughout.

All the departments of the finished iron trade in the Cleveland district are in a fairly prosperous condition, and there is every reason to believe that this year the staple industry will be in a better state than it has been in since the last money panic and the depression which followed it.

A new marble has been discovered in the Giant Mountains of Bohemia, which is described as in every way equal to Carrara, both in whiteness and fineness of grain, and invaluable for sculpture or for the purpose of trade when worked into table tops &c

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	From s.	From d.	To £	To s.	To d.
COPPER.						
Best selected, per ton	73	0	0	74	0	0
Tough cake and tile do.	72	0	0	73	0	0
Sheathing and sheets do.	77	0	0	,,	,,	,,
Bolts do.	78	0	0	,,	,,	,,
Bottoms do.	80	0	0	,,	,,	,,
Old (exchange) do.	64	0	0	,,	,,	,,
Burra Burra do.	73	10	0	,,	,,	,,
Wire, per lb.	0	0	10½	,,	,,	,,
Tubes do.	0	0	11½	,,	,,	,,
BRASS.						
Sheets, per lb.	0	0	8½	0	0	9
Wire do.	0	0	8	,,	,,	,,
Tubes do.	0	0	10½	,,	,,	11½
Yellow metal sheath do.	0	0	6½	0	0	7
Sheets do.	0	0	6½	,,	,,	,,
SPELTER.						
Foreign on the spot, per ton	19	10	0	19	15	0
Do. to arrive	19	10	0	19	15	0
ZINC.						
In sheets, per ton	24	0	0	,,	,,	,,
TIN.						
English blocks, per ton	117	0	0	,,	,,	,,
Do. bars (in barrels) do.	118	0	0	,,	,,	,,
Do. refined do.	118	0	0	,,	,,	,,
Banca do.	111	0	0	,,	,,	,,
Straits do.	111	0	0	,,	,,	,,
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	6	0	1	8	0
IX. do. 1st quality do.	1	12	0	1	14	0
IC. do. 2nd quality do.	1	4	0	1	6	0
IX. do. 2nd quality do.	1	10	0	1	12	0
IC. Coke do.	1	2	0	1	3	0
IX. do. do	1	8	0	1	9	0
Canada plates, per ton	13	10	0	,,	,,	,,
Do. at works do.	12	10	0	,,	,,	,,
IRON.						
Bars, Welsh, in London, per ton	7	0	0	7	10	0
Do. to arrive do.	7	5	0	7	10	0
Nail rods do.	7	5	0	7	10	0
Stafford in London do.	8	10	0	9	0	0
Bars do. do.	8	7	6	9	0	0
Hoops do. do.	9	0	0	10	15	0
Sheets, single, do.	10	0	0	12	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	0
Bars, common, do.	6	5	0	6	10	0
Do. mrch. Tyne or Tees do.	6	10	0	,,	,,	,,
Do. railway, in Wales, do.	7	5	0	7	10	0
Do. Swedish in London do.	10	0	0	10	5	0
To arrive do.	10	5	0	,,	,,	,,
Pig No. 1 in Clyde do.	2	18	6	3	5	6
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. No. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	10	0	5	15	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pig in London do.	6	0	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	14	0	0	,,	,,	,,
Do. (hammered) do.	14	15	0	15	5	0
Do. in faggots do.	15	15	0	16	0	0
English spring do.	19	0	0	23	0	0
Quicksilver, per bottle	6	17	0	,,	,,	,,
LEAD.						
English pig, common, per ton	18	15	0	,,	,,	,,
Ditto. L.B. do.	19	5	0	,,	,,	,,
Do. W.B. do.	20	5	0	,,	,,	,,
Do. sheet, do.	19	10	0	,,	,,	,,
Do. red lead do.	20	0	0	20	10	0
Do. white do.	27	0	0	30	0	0
Do. patent shot do.	22	0	0	,,	,,	,,
Spanish do.	18	7	6	,,	,,	,,

*At the works 1s to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

WE HAVE ADOPTED A NEW ARRANGEMENT OF THE PROVISIONAL PROTECTIONS APPLIED FOR BY INVENTORS AT THE GREAT SEAL PATENT OFFICE. IF ANY DIFFICULTY SHOULD ARISE WITH REFERENCE TO THE NAMES, ADDRESSES, OR TITLES GIVEN IN THE LIST, THE REQUISITE INFORMATION WILL BE FURNISHED, FREE OF EXPENSE, FROM THE OFFICE, BY ADDRESSING A LETTER, PREPAID, TO THE EDITOR OF "THE ARTIZAN."

DATED NOVEMBER 22nd, 1869.

3372 G. and J. Ritchie—Tents, weather protectors, &c.
3373 J. Tomlinson—Cements
3374 J. Brookes—Fastenings applicable to ladies' stays
3375 E. E. Allen—Tramways

DATED NOVEMBER 23rd, 1869.

3376 H. A. Bonneville—Steam boiler supply cock
3377 H. A. Bonneville—Electro metallurgy
3378 H. A. Bonneville—Electric batteries
3379 S. G. Arnold—Saws
3380 J. E. C. Spinelli—Nautic means
3381 E. Round—Indicator
3382 W. E. Gedge—Hydraulic traction on railways and other roads
3383 H. F. Shaw—Cutters for moving machines
3384 A. Nairn—Steam carriages
3385 F. Foster—Gauges
3386 J. H. Johnson—Grinding saws
3387 H. C. Lobnitz—Engines

DATED NOVEMBER 24th, 1869.

3388 A. McNeill—Safe for ships carrying mails and other valuables
3389 F. J. Granville and H. Gardner—Advertising papers
3390 W. Thomas—Obtaining power
3391 J. Fogg—Dressing stone
3392 S. Cotton—Preparing flax
3393 J. Norris and E. Longworth—Placing fog signals
3394 J. and B. Dunkerley—Felting or planking the bodies of hats
3395 J. B. Paddon—Gas
3396 D. Miles—Lighting and extinguishing gas by electricity
3397 J. Turnbull—Connecting and disconnecting railway carriages
3398 S. Chatwood and T. Sturgeon—Drawing and forcing fluids
3399 M. Henry—Moving railway carriages and other heavy bodies
3400 J. Downs—Presses
3401 W. C. Mann—Hats

DATED NOVEMBER 25th, 1869.

3402 P. C. Evans and H. J. H. King—Feeding carding machines
3403 F. W. Webb—Steam engines
3404 T. Richardson—Desks
3405 J. Nichols—Polishing yarns
3406 B. Goddard and W. Finley—Making and mixing pills
3407 E. F. Goodall—Ink bottles
3408 W. R. Lake—Propelling ships
3409 B. Johnson and E. B. Ellington—Moving weights
3410 A. McDougall—Blacking
3411 T. Brown—Boring rocks
3412 L. Mount—Filling match splints
3413 J. Keats—Buckles
3415 W. E. Gedge—Destroying the parasites in the wood of trees
3416 W. Pollitt and W. J. Knowles—Washing fluids

DATED NOVEMBER 26th, 1869.

3417 D. Barker—Varnish
3418 J. Denis—Paper
3419 J., J. and W. Fletcher—Mortar mills for pulverising
3420 S. Tatton—Reels
3421 S. Tatton—Card for the withdrawal of single threads for sewing
3422 E. H. Burke—Metallic barrels
3423 B. Wood—Lids for railway axle boxes
3424 W. Perkins—Fusees
3425 J. Combe—Hackling flax
3426 A. C. Engert—Ornamental placards and such like articles
3427 J. Brunton—Working railway points and signals
3428 S. Wyatt—Preserving meat

DATED NOVEMBER 27th, 1869.

3429 H. S. Freeman—Adjustment of men's wearing apparel
3430 F. Preston—Preparing fibrous substances
3431 W. C. S. Percy—Cutting animal and vegetable substances
3432 A. Barclay—Condensers
3433 G. Bertram and M. Patterson—Straining paper pulp
3434 J., J. E., and W. Pitt—Cutting metals and other materials
3435 L. Pochet—Dressing stone
3436 W. Johnson—Lock fastenings
3437 J. Howard and E. T. Bousfields—Cutting standing crops
3438 A. E. Loram—Buckles
3439 W. Cross—Shawls
3440 G. Lockett—Revolving graphoscope
3441 W. Brookes—Sewing machines
3442 B. Oldfield—Looms
3443 S., J. J., and L. H. Perry—Boxes
3444 S. Fox and J. Reffitt—Turning and polishing treenails

DATED NOVEMBER 29th, 1869.

3445 J. Moseley—Blankets
3446 G. B. McFarland—Convertible double centre rotary engine
3447 E. Lethbridge—Balancing millstones
3448 J. Williams—Cooking
3449 J. Tester—Cutting chaff
3450 E. Oades—Vent plugs
3451 T. Rossig—A new derivative of phenol
3452 J. C. Mewburn—Obtaining motive power
3453 H. Draper—Tanning
3454 G. and A. B. Marquis—Cutting metal or other sheets
3455 J. Edward and J. Quin—Preventing roller laps
3456 W. R. Lake—Journal bearings for railway carriages
3457 W. Harham—Horticultural buildings
3458 J. Speight—Spinning and twisting worsted substances

DATED NOVEMBER 30th, 1869.

3459 W. H. Shaw and J. M. Audus—Dressing mill stones
3460 J., J., and W. H. Wood—Hats
3461 C. H. Hudson—Bedsteads
3462 E. T. Hughes—Springs
3463 A. W. Pocock—Meters
3464 W. H. Willis—Indicating the points of games
3465 B. Aston and J. Mustard—Feeding carding engines
3466 W. Avery—Umbrellas
3467 E. Ensor—Kilns
3468 A. V. Newton—Converting reciprocating into rotary motion
3469 R. Milburn and T. Browning—Drying machines
3470 J. F. Crease—Tank filters
3471 R. Hornsby and J. E. Phillips—Reaping and mowing machines

DATED DECEMBER 1st, 1869.

3472 W. Spence—Soda crystals
3473 T. G. Green—Earthenware
3474 J. Forbes—Desiccating grain
3475 J. James—Stamping letters
3476 A. C. Henderson—Shearing animals
3477 J. T. Griffin—Rendering sponge suitable for stuffing beds
3478 W. Bennett and J. Currall—Kitchen ranges or stoves
3479 F. N. Target—Waterclosets
3480 J. Peirce—Sawing wood
3481 W. Richards—Firearms
3482 H. C. Ash—Churns
3483 R. Rubey and J. Richardson—Steam engine governors
3484 R. N. Slight and W. F. Denholm—Straining paper pulp
3485 G. Hammer—Cork cutting machines

DATED DECEMBER 2nd, 1869.

3486 H. C. Pannell—Rifles
3487 J. B. Wilson, J. Higginbottom, and I. Royse—Rollers
3488 A. Mitchell—Caissons
3489 F. C. Webb—Cables
3490 A. P. Stirling—Railway spittoon
3491 J. H. Johnson—Spring mattresses
3492 H. H. Mayden—Spinning tobacco
3493 J. W. and E. Whittaker—Furnaces
3494 P. A. S. Langlois and L. S. Thomassin—Sulphuric acid
3495 E. Field—Valves

DATED DECEMBER 3rd, 1869.

3496 W. Tatham—Opening and breaking hard waste rags of cotton
3497 J. Smith and T. Eastwood—Reversing valves of steam engines
3498 J. M. Macintosh—Laying sheets of paper delivered by paper cutting machines
3499 J. C. Wilson—Revolving engine
3500 W. Mcllan—Printing
3501 J. Jenoons—Armour plates
3502 E. V. Neale—Fastening objects capable of rotating on hinge joints
3503 T. W. Tobin—Telegraphs
3504 T. R. Crampton—Burning powdered fuel
3505 H. Larkin and W. White—Production of potassium
3506 J. and S. Loehl—Locks

DATED DECEMBER 4th, 1869.

3507 J. Boyd—Winding yarn
3508 C. W. Petersen—Lifeboats
3509 J. F. Kent—Sawing machines
3510 H. M. Nicholls—Cutting continuous paper into sheets
3511 S. Alley—Breakwaters
3512 J. Knowles—Rotary engines
3513 J. Walker—Washing blankets
3514 H. Alexandre—Organs
3515 W. Brookes—Fluid lenses
3516 T. Macguire—Packing glands of steam and other engines
3517 A. Ripley and J. Wormald—Pipe wrench
3518 W. R. Lake—Harness
3519 T. Clark—Covers of parasols
3520 S. Chatwood and J. Crompton—Valves

DATED DECEMBER 6th, 1869.

3521 J. L. Booth—Rails for railroads
3522 T. Prideaux—Purifying limes
3523 W. Thanks—Forging horse shoes
3524 H. H. Murdoch—Joining the ends of iron and other tubes
3525 J. B. Spence—Alum
3526 J. B. Spence—Paper
3527 W. R. Lake—Hulling grain
3528 W. Geeves—Packages for containing tea

DATED DECEMBER 7th, 1869.

3529 D. Robertson, W. L. G. Wright, and J. More—Forcing fluids
3530 S. Lewin—Raising straw
3531 H. P. de Meyrignac—Brushing and wetting the hair
3532 J. Swift—Safety lamps
3533 G. Dowler and W. Pursall—Breech-loading firearms
3534 J. Jonas Packing tea
3535 B. J. R. Mills—Securing bales of fibrous and other substances
3536 W. Scott—Furnaces
3537 J. Watson—Electric telegraph apparatus for continuous printing
3538 C. Vavin—Separating metals
3539 F. A. Harrison—Buckles
3540 J. Childs—Biscuits
3541 J. H. Johnson—Crucibles
3542 C. Wyndham—Velpcipedes

DATED DECEMBER 8th, 1869.

3543 E. Edwards—Photo-mechanical printing and reproduction of designs
3544 J. S. Robertson—Horseshoes for snowy or frosty weather
3545 M. Kolb—Screw propellers
3546 E. Weldon—Cooking food
3547 M. Stell—Doubling worsted or other fibrous substances
3548 G. Preston and J. Prestige—Regulating the water supply to waterclosets
3549 B. F. Stevens—Working of glass
3550 M. F. Anderson—Treating sewage
3551 A. L. Bricknell—Gates
3552 A. M. Clarke—Ornamenting muslin and gauze fabrics

DATED DECEMBER 9th, 1869.

3553 H. S. Rush—Railway chairs
3554 E. Walker—Gas burners
3555 W. Johnson—Pressing wool
3556 H. Byk—Refining paraffin and rendering it white
3557 W. Tranter—Firearms
3558 J. Loader and W. H. Child—Meters
3559 D. Clayton—Shuttles
3560 C. Sipriot—Exhibiting placards
3561 J. Hamilton and R. Paterson—Collapsable casks
3561 W. R. Rake—Vices
3563 J. F. Alexander—Propellers
3564 R. A. Ballon—Safes
3565 C. A. McCalla—Stoppering bottles and such like articles
3566 J. Ballontyne—Yarns

DATED DECEMBER 10th, 1869.

3567 H. Whittaker and W. Bradbury—Connecting the ends of hoops
3568 H. Kershaw—Spinning
3569 G. F. Logan—Utilising heat
3570 W. E. Gedge—Velocipedes
3571 J. Willis—Umbrellas
3572 T. S. Sarney—Fishing or connecting railway wheels
3573 A. M. Clark—Ornamenting brooches
3774 W. Baines—Actuating railway signals and switches
3575 R. J. Ransome, J. Deas, and R. C. Napier—Tramways
3576 W. Yeoman and J. Gilbert—Seing machines

DATED DECEMBER 11th, 1869.

3577 W. Downing—Cartridges
3578 J. Parnett—Fuel
3579 G. White—Steering ships
3580 T. Sager and T. Richmond—Looms and healds for weaving
3581 A. A. Croll—Treating ammoniacal liquor of gasworks
3582 W. E. Newton—Folding paper
3583 J. T. Parlour—Raising sunken ships
3584 E. Simon—Portfolios
3585 W. I. Hetherington—Engines
3596 T. Moore—Door knobs
3587 W. A. Marshall—Telegraph cables
3588 H. and F. C. Cockey—Steam boilers
3589 W. C. Green—Firearms
3590 H. Wilson—Cutting timber
3591 W. Williams—Subaqueous and tunnel communications

DATED DECEMBER 13th, 1869.

3592 T. Rawsthorne—Putting twist into yarn from the flyer eye to the front rollers of frames for fibrous substances
3593 P. Koch—Untapped nuts
3594 J. and J. Turner—Lubricators
3595 H. Watson—Smoothing bobbins
3596 G., J., and M. Oldroyd—Weaving
3597 W. R. Lake—Preserving dead human bodies and animal carcases
3598 J. G. ToBgue—Sewing together separate parts of a volume
3599 E. A. Cowper—Sieves
3600 P. C. Evans and H. J. H. King—Feeding wool to carding machines
3601 A. Barr—Blowing organs
3602 W. Asquith, G. Booth, and G. Pickersgill—Cutting metals
3603 H. E. Newton—Net machines
3604 R. J. Carpenter—Iron
3605 J. Gardner—Cutting veneers
3606 R. W. Bernard—Candle lamps or imitation candles
3607 J. Livesey—Tramways

DATED DECEMBER 14th, 1869.

3608 T. Moore—Castors for sofas, pianos, and other purposes
3609 J. Barlow—Looms
3610 B. B. de Morell—Raising vessels above the surface of the water
4611 W. Hepple and M. Stainton—Furnace bars and furnaces
3612 W. and W. McGee—Machinery for winding fibrous substances
3613 R. Morton—Refrigerators or apparatus for cooling
3614 P. Parks—Cutting screw nuts and the heads of bolts
3612 W. E. Newton—Improvements in harness for looms
3616 W. E. Newton—Improvements in rotary engines
3617 G. W. Honeymann—Prevention of incrustation in boilers

DATED DECEMBER 15th, 1869.

3618 W. C. Homersham—Pipes and conduits and in the joints thereof
3619 N. P. Burgh—Improved double or single acting pump
3620 W. R. Lake—Making and breaking electro-magnetic circles
3621 E. Muss—Drying malt
3622 E. Johnson—Arrangement and construction of granaries
3623 W. K. Stock—Looms
3624 J. Hamer—Steam engines
3625 J. Askew—Refrigerator for cooling distillers wort
3626 J. Outram—Propelling ships
3627 J. H. Sams—Seed sowing machine and manure distributor
3628 E. T. Hughes—Wood-moulding and panelling machines
3629 T. Parry and J. McHardy—Brake applicable to waggons
3630 A. Hall—New fabric, called Tartan Reversible Astrachan
3631 G. Seymour—Facilitating the steering and propulsion of ships
3632 J. S. Battye—Machinery for spinning woollen yarns
3633 J. H. Johnson—Reducing friction

DATED DECEMBER 16th, 1869.

3634 J. Heap—Urinals
3635 E. Tomlinson—Furnaces for the prevention of smoke
3636 J. W. Greenwood Buckle fastener
3637 W. T. Henley—Protecting telegraph wires and cables
3638 S. Johnson—Velocipedes
3639 J. O. Butler—Wheels
3640 G. Wilson—Railway wheels
3641 W. Richards—Firearms
3642 J. Outram—Engines
3643 S. A. Buirat—Engraved metalic plates
3644 F. E. Duckham—Weighing machines
3645 A. M. Clark—Superphosphate of lime

DATED DECEMBER 17th, 1869.

3646 J. Gassi—Spherical ship
3647 A. R. Stocker—Bottle stopper
3648 H. Willett—Breastworks
3649 L. Sterne—Buffers
3650 G. Weir—Slide valves
3651 W. Foulds—Feed-water heaters
3652 W. Burrs—Elastic webbing
3653 R. Idll and G. Naylor—Smoke consuming apparatus
3654 E. A. Inglefield—Utilising the pressure of the external water
3655 J. L. Hancock—Crushing bones
3656 T. C. March—Ornamenting furniture
3657 G. Rhodes—Valves
3658 A. M. Clark—Jacquard apparatus

DATED DECEMBER 18th, 1869.

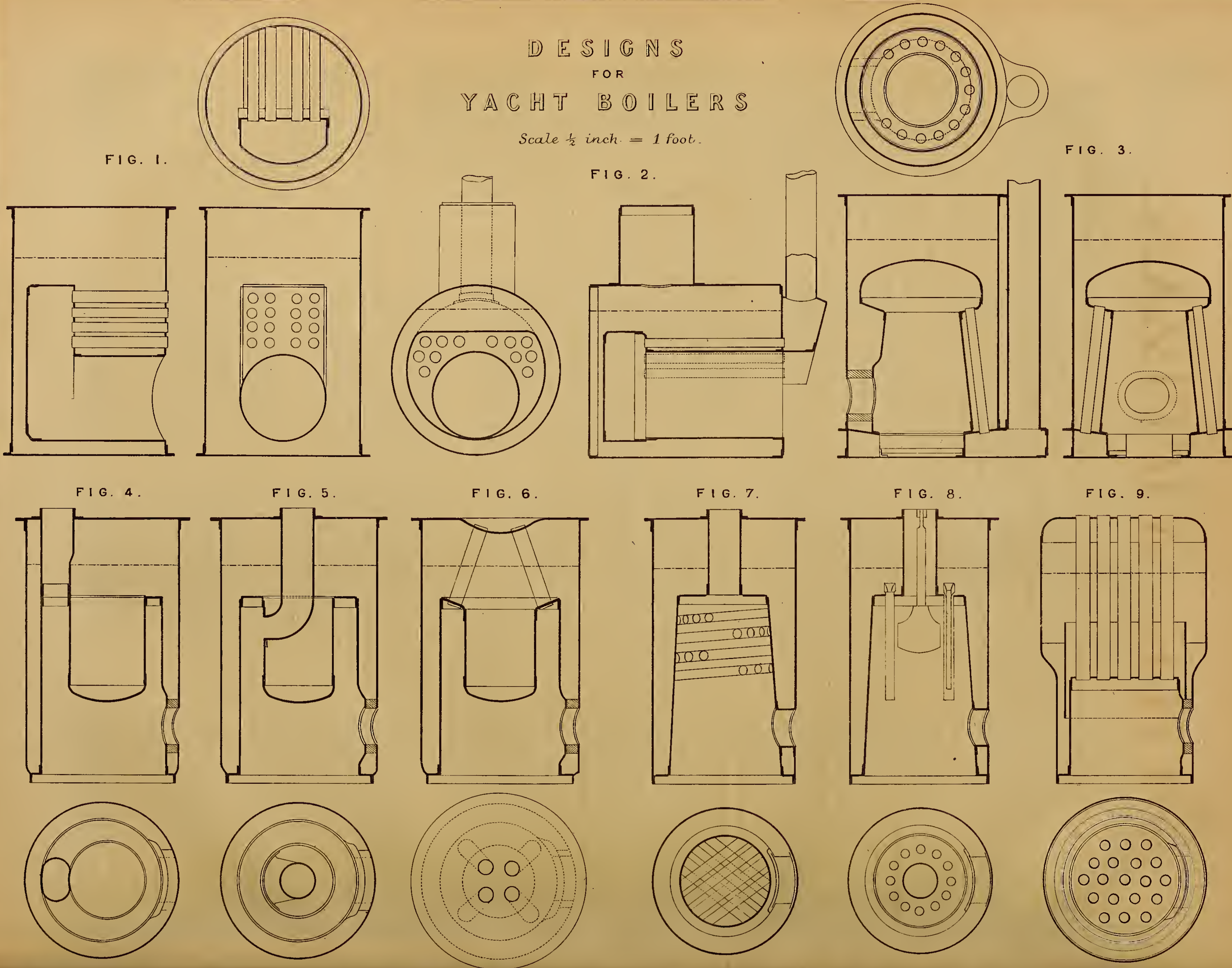
3659 W. Carver—Sewing machines
3660 R. C. Goddard—Cooking apparatus
3661 J. C. Martin—Finings for clarifying wines and beer
3662 W. E. Gedge—System of pessary
3663 W. Hargreaves—Steam boilers
3664 W. Foulds—Steam boilers
3665 J. Smiles—Firearms
3666 W. Batts—Ventilation
3667 R. Nevill—Retorts
3668 J. C. Ramsden—Looms
3669 J. M. Shiels—Preparing grain
3670 S. Butler—Lace
3671 S. Giles—Fermentation of worts
3672 D. W. Boilay—Laying composite pavements for streets
3673 H. Kinsey—Surface condensers
3674 L. Woodward—Knitting frames
4675 G. T. Bousfield—Obtaining colouring matter
3676 W. L. Wise—Instrument for measuring and levelling angles

DATED DECEMBER 20th 1869.

3677 J. Robertson—Shaping metals
3678 G. Ermen—Brushes
3679 M. Henry—Composing types
3680 F. Elleishausen—Utilising the force of the waves
3681 G. Newsum—Pumping
3682 G. T. Livesey—Gas
3683 W. Morris—Permanent way
3684 E. T. Hughes—Garments to be worn next the skin
3685 J. Wild—Pile fabrics
3686 J. H. Richardson—Boxes for carrying eggs
3687 C. D. Abel—Ploughs
3688 T. Shakapear—Sewing machines
3689 A. M. Silver—Indicating time
3690 W. Galloway—Couplings for pipes
3691 G. C. Froser—Disinfecting clothes

DESIGNS FOR YACHT BOILERS

Scale ½ inch = 1 foot.



W. Smith. C.E. direx.

THE ARTIZAN.

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1st. FEBRUARY, 1870.

DESIGNS FOR YACHT BOILERS.

(*Illustrated by Plate* 357).

During the past few years an extraordinary number of small steam yachts have been called into existence, and when it is considered how remarkably handy these little craft are in consequence of their thorough independence of wind and tide, it is only a matter of surprise that they should not be even still more numerous. In vessels of this description, more especially in those of the smaller class, condensing engines would be inapplicable, as it is essential that the machinery should be light and compact, and also that it should be sufficiently simple to be managed by amateurs. Nearly all of these boats are, therefore, fitted with non-condensing engines, but as this system also necessitates high pressure steam, it, to a certain extent, increases the difficulty with regard to the boilers. The great number of different forms of boilers at present to be found in those yachts is extraordinary; in many instances the vessel appears to be all boiler, in other cases the most energetic stoking fails to supply a sufficient quantity of steam, and not unfrequently the boiler reaches to such a height that the stability of the boat is endangered.

There are, of course, many honourable exceptions to these anomalies, but the great prevalence—we might almost say, preponderance—of badly-shaped or badly-proportioned boilers in steam yachts, has suggested the accompanying Plate (357), illustrating various systems of boilers suitable for this purpose, and which may possibly be of assistance to some of our readers. It is not to be supposed that the designs here given include nearly all the different systems that might be advantageously adopted, many having been omitted as being too well known to require reproduction. Thus, the type of boilers adopted for the launches of H.M. navy, together with the excellent design of Messrs. Allibon and Manbré are omitted, having been already illustrated in The Artizan. The boilers shown in the accompanying Plate (357) are all drawn to the same scale, viz., half an inch to the foot, and are calculated to be of sufficient power to supply a five-inch cylinder with 60lbs. steam. The drawings for each design are so explanatory in themselves that but few remarks upon them are needed. Fig. 1 shows two sectional elevations and plan of an upright cylindrical boiler, having return tubes. The uptake is not shown, but is intended to be of the usual description, as shown in Fig. 2. The form of a vertical cylinder possesses many advantages for high-pressure boilers for small boats, as it takes up very little floor space, is but slightly affected by the variations in the trim of the boat, and at the same time affords a sufficient amount of steam space. It may be objected that the tubes of this boiler are very short, but it is a well-known fact that the first 18in. of the tubes in tubular boilers absorb by far the greater portion of the heat, even when those tubes are 10ft. long. The horizontal cylindrical boiler, with return tubes, shown in Fig. 2, is too well known to require any remarks except that it has been proved to be very serviceable when sufficient floor-space is available. Fig. 3 is an ingenious design for a boiler with a down draught, and one which, we think, would prove to be very efficient and economical. At Fig. 4 is shown a sectional elevation and plan of a pot boiler, which has lately received considerable attention. This class of boiler, modifications of which are shown in Figs. 5 and 6, is said to make steam very rapidly; it is also asserted that the violent ebullition in the "pot" prevents any accumulation of deposit on its bottom, but we think great care should be exercised that the water should not be so dirty that, when the fire was drawn and the ebulition ceased, a deposit could then be formed. These boilers would probably be improved by the addition of a circulating plate, as shown in the annexed

engraving. The water tube boiler shown at Fig. 7 (Plate 357), has been found to be a very effective steam generator; the only drawback being the necessity for having manholes opposite the tubes for the purpose of cleansing and repairs. The Field boiler, shown at Fig. 8, is too well known to need description. The remarks made above respecting the necessity of clean water when working with a pot boiler, are perhaps still more applicable to this class of boiler. The upright tubular boiler is an old favourite with some engineers, and in Fig. 9 one of this class is given, with the addition of a circulating plate, which would assist in keeping the tube plate clean. In working these boilers care should be taken that the water level should be kept sufficiently high to prevent the tubes getting too hot just above the water line.

Although, as we have before remarked, there are many other forms of boiler which might have been included in this list, we think that a sufficient number of designs have been brought forward to enable our readers to decide upon a suitable form of boiler for their purpose. It is evident that, although these designs have been given for the smallest size of boiler that would probably be required, their dimensions may be increased to any size that may be necessary. In steam yachts of small tonnage great difficulty is often experienced in obtaining a boiler that will supply sufficient steam, while at the same time it does not cut off the communication between the fore and after parts of the boat, and one of the objects kept in view in these designs is to show how this inconvenience may be overcome. In larger boats, of course, no such difficulty is found, whatever may be the form of the boiler, and consequently more elaborate designs may be preferred; we are, however, of opinion that for non-condensing engines, one or the other of the forms given in Plate 357 might be advantageously adopted even for a much greater power.

ON THE MANUFACTURE OF CRUCIBLE STEEL.

By R. H. Smith, F.C.S., &c.

A great deal is being talked about the production of cast-steel directly fron iron ores, or its manufacture from inferior kinds of English iron; but little is known or said (outside the immediate manufacturing districts) as to how the immense quantities of this substance are produced at the present time. The conversiou of iron into steel is, perhaps, to be classed among one of the most peculiar, but, at the same time, interesting processes with which chemists are acquainted.

The ordinary converting furnaces are of a conical shape, the bar-iron laying in stone pots, in contact with charcoal; and the heat to which the iron is exposed is regulated according to the purpose for which it may afterwards be required. The time generally occupied in what is termed "couversion" is about three weeks, a week being taken to raise the heat to a sufficient degree, a second to maintain it at the required temperature, and a third to gradually cool the furnace. When cold, the bars are withdrawn, and found to be covered with blisters, and, if broken, possessing a fracture totally different in appearance to that shown by the iron before treated in the manner described. Several tempers, as they are technically called, are produced in one furnace, and much care is necessary in selecting them out for the different requirements of the melter.

Too much care cannot be taken in the melting of steel, as the after work so much depends upon this part of the process. The melting-holes are on a level with the floor of the furnace-room. Each hole has a flue; and some six, twelve, or more, of these form a flat stack. The grate bars at the bottom of each hole are approached by means of a cellar below. The crucibles, or pots, as they are called, made from a mixture of several kinds of clay and a little coke-dust, are formed into shape by means of a plug and flask. The pots are annealed over night, and when at a dull red heat in the morning placed in the holes by means of tongs, each furnace taking two pots.

The bar-steel of the required hardness is now broken up, and the crucible charged by means of an iron funnel. The first heat, as it is called, will take from four to five hours before it is ready to be poured; but this greatly depends on the nature and hardness of the steel. The holes are watched and worked by the puller-out; but the word to draw the pot is given by the melter.

The puller-out now lifts the crucible from the hole with large tongs, and places it upon the floor of the furnace. Its contents are then poured by the melter into a mould, made of cast-iron in two pieces, covered with a coat of coal-tar soot, and held together by rings and wedges.

Great care is required in pouring or teaming the steel, as it is technically called, and skill in judging the proper heat when to cast it. Mild or soft steel should be teemed immediately the pot is withdrawn from the furnace; but hard steel may often remain a few minutes with advantage. Each crucible should last one day, and is used three times, with charges of 50, 45, and 40 lbs. respectively.

All steel above a chisel temper contains 0·90 to 1·00 per cent. of carbon. If well melted it will settle down in the mould, leaving a small hole at the top of the ingot. If, however, the molten steel has not remained long enough in the fire, it will pour fiery; and, if the ingot, on cooling, be broken, it will be found to be full of small holes, called honeycombs. Great precaution must also be used in not allowing the metal to remain too long in the fire, as hard steel, when of good quality, will soon scorch, and so render the ingot very brittle.

Well melted, steel (say of a cool temper) may be thus known. The ingot will be of a blue colour, with a smooth and even skin; the fracture of uniform brightness, and the outer edge perhaps slightly scorched.

Another very important operation to which steel is subject is the hammering; and probably more good steel is spoiled in this department than any other. The ingot should be well soaked in the flame of the forge furnace, and not at once (as is often the case) put into a dead fire—where the heat is what is called dead, and where no flame surrounds the ingot.

The fineness of the fracture of a bar of finished steel greatly depends upon the heat that the bar is allowed to retain when the finishing stroke of the hammer is upon it. Coarseness and fineness of grain, as judging the temper or quality of cast-steel, is far over-estimated. It is, to a certain extent, an indication of hardness; but so much depends upon the way the bar has been finished, that it is of little practical value. However, best cast-steel, especially when hard, will show a fracture of a silky nature; and when soft, will look bright, and shine like glass. Common cast-steel, on the other hand, will lack that brightness which is so characteristic of good steel; it will look dull, and have, so to speak, a leaden appearance about it.

In the working of steel too much care cannot be bestowed; and where, as in razor making, the workman is required to use a steel containing 1·50 per cent. of carbon, the durability of the razor will almost entirely depend upon the heat to which he subjects it while forging it into shape.

A useful tool-steel will contain about 1·2 to 1·35 per cent. of carbon. Spindle-steel, or large size turning tools, will work well if containing about 1·15 per cent. of carbon. Chisel-steel is a temper much used, will harden at a low heat, and possesses great toughness. Steel of 0·85 to 0·75 per cent. of carbon will weld easily, and is adapted for cold-setts, or tools where the principal punishment is on the unhardened part.

In melting, charcoal is largely used when the bar-steel is not of the required hardness. Wolfram and titanium are occasionally used, but with little advantage.

Binoxide of manganese is universally employed. It forms a good flux, aud protects the molten steel from the action of the air.

Spiegeleisen is much used in Sheffield. It is an alloy of iron with manganese and carbon. The following is an analysis of a good spiegeleisen:—

Iron (by difference)	84·78
Manganese	10·21
Carbon	5·01
	100·00

Among the many irons employed in steel-making, none have acquired the reputation that those imported from Sweden have won for themselves, and especially those known as the Dannemora marks.

Such brands as double Bullet (OO) and hoop L (L) command a high price, and are much used where the best quality steel is required. Second Swedes, such as Wand Crown, Steinbuck, Great S, K6, &c., are good bodied irons, largely employed, and making a very good steel. Of the commoner marks may be quoted (CW) (SV8) Spider, and I-G (m); and, where a high price cannot be obtained for the steel, such brands are recommended, being found to melt and work well. English irons and spring ends are melted, but make an inferior quality of cast-steel.

The following is au analysis of tool-steel:—

Iron (by difference)	88·34
Carbon	1·31
Manganese	0·12
Silicon	0·19
Sulphur	0·03
Phosphorus	0·01
	100·00

TRIAL TRIP OF H.M. CORVETTE "VOLAGE."

On the 29th of December the *Volage* made her Channel trial of six hours' continuous steaming at full power off the Isle of Wight, under the superintendence of the officials of Portsmouth Dockyard, Reserve, and Factory, and attained an unprecedented amount of success, her mean rate of speed for the six hours having exceeded the rate she attained on her trial over the measured mile in Stokes Bay, her mean speed on the latter occasion having been 15·07 knots per hour, whereas at this trial her six hours' Channel steaming gave her a mean rate of 15·38 knots. The *Volage* slipped her moorings in Portsmouth harbour at seven o'clock, and soon afterwards was steaming through the harbour channel for the open waters of the Channel south of the Isle of Wight. At 8.30 a.m., she being then in a good position off the east end of the Isle of Wight, Sandown Bay opening out on the starboard beam clear of the Culver cliffs, a start was made for the six hours' trial on a course S.W., the ship being weighted down to her load line draught of water of 16ft. 6in. forward and 21ft. 6in. aft. The wind was quite moderate (ranging not above 3 at the time of starting) from about west, and therefore on the ship's weather bow. The steam was barely at its best at the time of starting, the guage showing but 25lb. pressure, and the revolutions of the engines, consequently, were at 74 per minute, their considered maximum rate being 80. Three hours were spent in steaming from off the land on the S.W. course, and the remaining three in steaming back N.E., towards the Culvers again. Observations were taken every half-hour in the engine-room, and these gave the subjoined figures, taken from the indicator cards, in the more important results of the trial:—9 a.m.—Steam pressure, 27lb.; vacuum, 26·5in. and 26in.; revolutions of engines, per minute, 77·8; per half-hour, 2,335. 9 30.—Steam pressure, 28lb.; vacuum, 25·5in. and 25·7in.; revolutions of engines, per minute, 79; per half-hour, 2,335. 10 a.m.—Steam pressure, 26·5lb.; vacuum, 25·7in. and 26in.; revolutions of engines, per minute, 77·5; per half-hour, 2,286. 10 30 a.m.—Steam pressure, 25·5lb.; vacuum, 25.7in. and 26in.; revolutions of engines, per minute, 76; per half-hour, 2,253. Fires cleaned during this half-hour, and the steam lowered in consequence. 11 a.m.—Steam pressure, 27lb.; vacuum, 25·5in., revolutions of engines, per minute, 77·6; per half-hour, 2,326. 11 30 a.m.—Steam pressure, 27in.; vacuum, 25in. and 26in.; revolutions of engines, per minute, 78; per half-hour, 2,353. The last two half-hour returns give a marked increase in developed power by the engines, and illustrate much more clearly than any words could do the splendid manner in which Penn's machinery was now working. The ship had reached a distance of 44.9 knots on a S.W. course from her starting point off the east end of

Sandown Bay, with 13,888 revolutions of her engines, and, as the firs half of the trial was now concluded, the course was reversed for a north-easterly one in a three hours' back steaming for the Culvers.

The following returns give the half-hourly figures obtained in the three hours' run back for the Culvers:—12 noon.—Steam pressure, 28lb.; vacuum, 25in. and 25·5in.; revolutions of engines, per minute, 80·9; per half-hour, 2,427. 12 30 p.m.—Steam pressure 28lb.; vacuum, 26in.; revolutions of engines, per minute, 80·5; per half-hour, 2,417. 1 p.m.—Steam pressure, 28·5lb.; vacuum, 26in.; revolutions of engines, per minute, 81·6; per half-hour, 2,449. 1 30 p.m.—Steam pressure, 28·5lb.; vacuum, 25·5in. and 26in.; revolutions of engines, per minute, 81·6; per half-hour, 2,449. 2 p.m.—Steam pressure, 28·5lb.; vacuum, 26in.; revolutions of engines, per minute, 81; per half-hour, 2,430. 2 30 p.m.—Steam pressure, 27·5lb.; vacuum, 26in. and 25·5in.; revolutions of engines per minute, 80·9; per half-hour, 2,419. Total number of revolutions made by the engines during the six hours, 28,478; mean horse power indicated during the six hours, 4,504·10; mean speed of the ship during the six hours, 15·38 knots; coal burnt during the six hours, 42 tons 6 cwt.—7 tons 1 cwt. per hour, or at the rate of 3·5lb. per horse power indicated.

THE WATER SUPPLY OF SYDNEY.

The commission appointed to inquire into the best means of supplying Sydney and its suburbs with water, have lately submitted their report to Parliament. Their labours have extended over a period of two years. In their report they have given the outlines of a scheme which seemed to them on the whole to be superior to all others examined, and they therefore agreed to recommend its adoption—the scheme, namely, of bringing down the waters of the higher affluents of the river Nepean by gravitation. The catchment area is 354 square miles in extent. The rivers that drain the selected district take their rise mostly in swampy flats between 1,200 and 1,600ft. above the sea; but at the confluence of the Corbeaux with the Nepean, where it is proposed to make the first interception of the waters, the height is 430ft. In regard to extent of surface, purity of water, freedom from sources of contamination, want of value in the land for others purposes, and altitude above the sea, the commission consider that there is in this scheme all that can be desired; the great drawback is the distance from Sydney (63 miles measured along the proposed conduit), which, though not important in an engineering point of view, will necessarily be a source of great expense. Instead of constructing dams, it is proposed to construct one large reservoir apart from the rivers, where they would not be subject to floods. Good sites for reservoirs have been found near Prospect, 21 miles from Sydney. It is proposed to convey the waters to Prospect by means of canals, tunnels, and raised aqueducts. Two methods for bringing the water from Prospect to Sydney have been considered by the commission. First, a high level scheme, by which the water would be impounded at a maximum height of 260ft. in a large reservoir, with a possible additional height of 20ft. by means of a small reservoir higher up—the water to be brought down to Sydney (a distance of 21 miles) in pipes. And, second, a low level scheme, by which a larger body of water would be impounded at a maximum height of 195ft., and be brought to Sydney by eight miles of open conduit, and thirteen miles of pipes. It was estimated that the high level scheme would cost £1,046,846, and the low level, £790,029. After prolonged deliberation the commission agreed to recommend the low service scheme for adoption. In concluding their able report (which was a very lengthy one) the commission point out reasons for believing that, costly as the work would be, it might be made productive.

H.M.S. "VANGUARD."

The new armour-plated twin screw steamer *Vanguard* was floated from the dry dock at the works of Messrs. Laird Brothers, Birkenhead, on the 3rd ult., and taken to the Alfred Dock, Birkenhead, to be prepared for sea. Mrs. Henry Laird performed the ceremony of christening, and the *Vanguard* was towed out without mishap. She is one of six vessels of the *Invincible* class, and is built to the design of Mr. E. J. Reed, the Chief Constructor of the Navy. These vessels are broadside ships, fully rigged as ocean cruisers, and are built on the central battery and armour belt system. The armour plating is 8in. at the water line and 6in. on the broadside, reduced, as usual, at the extreme ends, backed by 8in. and 10in. of teak respectively, and by 1½in. skin plating, with the usual arrangement of framing. The armour-plating is continued up to such a height above the upper deck for a portion of the length amidships, as to form an octagonal battery to protect four heavy guns mounted at the angles, the ends being enclosed by transverse iron-plated bulkheads. These guns can be fired in the line of keel as well as on the broadside, and, as they are a considerable height above water, can be fought in weather when the ports of the main deck battery cannot be opened. In combination with the six guns in the main deck battery, which have the ordinary broadside training, this arrangement gives large arcs of training to protected guns, every point on the horizon being commanded by one gun or another. The accommodation for officers and crew is in the unprotected parts of the ship, fore and aft of the battery, and is very commodious and well ventilated. The principal dimensions are are as follows:—Length over all, 300ft.; length between perpendiculars, 280ft.; breadth extreme, 54ft.; tonnage, 3,774ft.; draught of water abaft, 22ft. 6in. The engines, designed and made at Birkenhead, are two separate pairs of the ordinary horizontal double piston rod, with return connecting rod type, each pair driving a separate screw propeller 17ft. in diameter. The collective nominal power is 800-horse, and the indicated will not be less than 4,800. There are surface condensers, jacketted cylinders and other appliances for economising fuel. The 4 cylinders have each a diameter of 72in. with a stroke of 3ft. The steam is supplied from six boilers having 24 furnaces. The construction of the *Vanguard* was intrusted to Messrs. Laird Brothers in consequence of their competitive design for an armour-clad turret ship in 1867 being reported on as the best of the designs then submitted, and possessing great merits as a ship of war, although at that time the Lords of the Admiralty were not prepared to order another turret ship pending the construction of the *Captain*.

IRONMASTERS' QUARTERLY MEETING.

The second meeting of the ironmasters of this district for this quarter was held in the Town-hall at Birmingham on the 13th ult. The attendance was most unusually large, this having doubtless been stimulated by a feeling of anxiety on the part of all who are engaged in the trade to ascertain by the tone of the assembly itself what apparent prospect there is of maintaining the new list of prices. As it turned out, however, on that point there was much difference of opinion; and at present there is little guide to a definite conclusion on the subject. So far as might be judged from the amount of business transacted in the hall that day the result would be unfavourable; but the set-off to that is that buyers of every class will not operate to any extent at this early period of the year, and certain contracts and specifications for the foreign markets are said to be not yet ready to come out. The ordinary quarter-day contracts were given out as usual, but beyond that the business did not extend, and it may safely be said, that this was a quiet quarter-day. In reference to the terms upon which orders were accepted it would be difficult to speak with accuracy, but at least it may be said with a tolerable degree of safety that it is at an inconsiderable minority of the works only that the "list" prices are obtained, and that the weekly production just now falls short of what it was at the end of November. The result is that many of the men who are dependent for employment on the extent of operations at the mills and forges are very indifferently off in that respect. A slight impulse to the trade would have an immediately favourable effect, as finished iron is not being warehoused to any extent.

Hot-blast, all-mine pig of South Staffordshire and the district has gone up to £3 12s. 6d.; very favourable brands to £3 15s. per ton.

The Shropshire pig-masters have raised their prices; hot-blast may be quoted at £4 to £4 2s. 6d.; cold blast is quoted at £4 14s. per ton.

LONDON ASSOCIATION OF FOREMEN ENGINEERS.

The seventeenth annual general meeting of the members of this institution was held on Saturday, the 1st ult., at the City Terminus Hotel. The chair was occupied by Mr. Joseph Newton (Royal Mint), and the attendance was very good. After the routine business and nomination of new members had been accomplished, the auditors—Messrs. Edmonds and Gibbon—produced the balance sheet and their financial report. From these documents it appears that the total number of ordinary members is 108 and that of honorary members 61—total 169. The ordinary fund for meeting the working expenses of the society amounts to £459 13s. 11d.; the superannuation fund, the interest alone of which is used for the solace of decayed foremen, is equal to £1,016 17s. 4d.; and the widows' and orphans' fund stand at £15 4s. These items make a grand total of sums invested for all purposes equal in value to £1,491 4s. 3d.; and this exhibits a net increase during the twelve months of £146 14s. 4d. The balance sheet was deemed to be under all circumstances most satisfactory, and it was, with the auditor's report, unanimously accepted by the meeting.

The chairman next proceeded to deliver the annual address. This comprised a retrospective and comprehensive view of the history and progress of the institution during the past ten years. One of the most gratifying facts in regard to the present position of the association was (Mr. Newton said) the steady increasing friendship towards it of the employers of engineering labour throughout the kingdom. Ten years since not a single employer's name graced its books; now more than twenty of the most eminent of those gentlemen were enrolled as honorary members, and were liberal contributors to its benevolent funds. Many distinguished scientific men, apart from the engineering community, were also connected with the society, and assisted in promoting its charitable objects. Altogether, he (the chairman) considered that the Associated Foremen had real grounds for satisfaction. Still, more remained to be done. Was there any valid reason, for example, why young workmen who were desirous of advancing themselves in technical and practical knowledge should not be permitted to unite themselves as students, or otherwise, to the association? By such an arrangement the embryo talent of apprentices and assistants would be more speedily developed, and advantage would accrue to the entire engineering community. Employers would probably favour the scheme because they would benefit by the increased intelligence and usefulness of their young employés. Foremen would not fail to derive advantage from it, because the teachings of the lecture room would not fail to produce their fruits in the workshop, and conduce to a more intelligent realisation of their own orders and instructions. The pupils themselves would have a direct interest in the successful working of the plan, for they would reap immediate good from the lessons of experienced mentors; in short, the whole profession would find its interests advanced by the extension of the educational influences of the Association. "If such a moral stone were cast into the smooth water in which the Institution happily floated, the subsequent ripplings would extend far and wide, and the agitation could not fail to effect wholesome results." The chairman touched upon a variety of other topics, and especially referred to the independent societies of a similar kind to their own which had grown into vigorous existence at Manchester, Leeds, and Middlesborough, and which were in process of formation at Glasgow, Ferryhill, and Birkenhead. At all these places employers were co-operating, more or less, with their foremen, in supporting or founding these institutions.

After giving some brief particulars of deceased associates, invoking the more active aid of ordinary members at monthly meetings, and thanking the officers and members generally for their never-failing assistance and kindness to himself, Mr. Newton resigned the office of president, and vacated the chair. Thereupon Mr. Irvine was appointed chairman *pro tem.*, and Messrs. Briggs and Ives having proposed and seconded the re-election of the ex-president, Mr. Newton was for the eleventh time unanimously chosen to preside over the meetings of the association. Very reluctantly that gentleman consented to officiate for another year, and amidst loud demonstrations of approval again resumed his old post. Mr. Irvine was appointed vice-president, Messrs. Sissons, Welch, and Reed, junior committeemen, and Mr. Ives auditor for the ensuing year. The proceedings then came to a termination.

MANCHESTER STEAM-USERS' ASSOCIATION.

CHIEF ENGINEER'S MONTHLY REPORT.

The last ordinary monthly meeting of the Executive Committee of this Association was held at the Offices, 41, Corporation-street, Manchester, on Tuesday, November 30th, 1869, Sir William Fairbairn, Bart., C.E., F.R.S., LL.D., &c., President, in the chair, when Mr. L. E. Fletcher, Chief Engineer, presented his report, of which the following is an abstract:—

During the past month 285 visits of inspection have been made, and 650 boilers examined, 446 externally, 12 internally, 2 in the flues, and 190 entirely, while in addition 5 new boilers have been tested by hydraulic pressure, and specially examined both as regards their construction and equipment of fittings. In these boilers 84 defects have been discovered, 8 of them being dangerous. Furnaces out of shape, 8,—1 dangerous; fractures, 11,—3 dangerous; blistered plates, 8,—1 dangerous; internal corrosion, 14; external ditto, 9,—2 dangerous; internal grooving, 3; water gauges out of order, 5; blow-out apparatus ditto, 4; fusible plugs ditto, 1; safety-valves ditto, 3,—1 dangerous; pressure gauges ditto, 4; boilers without glass water gauges, 4; without pressure gauges, 4; without blow-out apparatus, 4; without feed back pressure valves, 2.

Injury to Furnace Crowns through the Use of Boiler Compositions, coupled with the Neglect of Blowing-out.

The attention of the members has previously been called to the great caution that should be exercised in adopting boiler compositions, and, more especially, in following the dangerous advice so frequently given, that when compositions are used, blowing-out should be given up. Such a course is completely suicidal as far as the boiler is concerned, a further illustration of which has just been met with.

This case occurred to a first-class boiler of the Lancashire type, in which the two furnace tubes were strengthened at each of the ring seams of rivets from one end of the boiler to the other with T iron hoops. One morning, as the fireman was about to charge his fires, the steam at the time being at a pressure of 55lb. per square inch, he noticed that both furnace crowns were bulging down at a little on one side of the centre line, though on looking at his water gauge, he found that he had a depth of between eight and nine inches of water over the furnace crowns. The engineer also tested the glass water gauge and found it as just stated but on account of the condition of the furnace crowns, had the fire at once withdrawn, and the steam blown off. It appears that an anti-incrustation composition was used in this boiler, and that the patentee of the composition had given instructions that the boiler should not be blown out till cleaning time, and, therefore, it had been worked on all bottled up for 340 hours. The water with which the boiler was fed was drawn from the river and left a sludgy deposit, which combining with the composition, which was of a glutinous character, formed, in the absence of blowing-out, a coating on the furnace crowns about an inch thick, and hence their distortion. It was fortunate that this was detected in time, or rupture might very shortly have ensued, and it is once more urged upon the members that they should turn a deaf ear to all recommendations to cease blowing-out.

Weak Unguarded Manhole.

Another case has recently been met with showing the importance of strengthening all manholes with substantial mouthpieces. The manhole in this instance, which was of the somewhat unusual shape of an oblong, rounded at the angles, was found to be fractured at three of the corners for a length of about an inch and a half in each case, so that a little more pressure of steam and a little more strain on the suspension bolts would have driven the cover right through the manhole, and thus have split the shell open and caused an explosion. Such explosions are numerous. They have been referred to again and again in previous reports, and it is once more recommended that every manhole should be strengthened with a substantial cast iron mouthpiece.

The Danger of Wide Brickwork Seatings.

The boiler in this case, though set on side walls, was not carried in suitable firebrick blocks, but let down on to the solid brickwork, with seatings as much as 8in. wide, in consequence of which, dangerous corrosion took place, and the plates, where resting on one of the side walls, were reduced for a length of about 9ft. to the thickness of a sheet of paper. Fortunately our Inspector detected this in time, and knocked a hole through.

Explosions.

Six explosions have occcurred during the past month, by which thirteen persons have been killed and sixteen others injured; but not one of these explosions has arisen from boilers under the charge of this association. Th scene of the catastrophe has been visited in three cases by the officers of this association, while in a fourth I have been kindly favoured with particulars from an engineer residing in the locality of the explosion.

The following is a tabular statement of explosions for the past month:—

Tabular Statement of Explosions,

From October 25th, 1869, to November 26th, 1869, inclusive.

Progressive Number for 1869.	Date.	General Description of Boiler.	Persons Killed.	Persons Injured.	Total.
42	Oct. 28	Plain Cylindrical, Egg-ended Externally fired	1	5	6
43	Oct. 29	Particulars not yet fully ascertained	0	1	1
44	Oct. 30	Two-flued 'Lancashire' Internally-fired	1	0	1
45	Nov. 2	Plain Cylindrical, Egg-ended Externally fired	0	2	2
46	Nov. 3	Multitubular Marine Internally fired	11	7	18
47	Nov. 25	Single-flue, or Cornish, Internally fired	0	1	1
		Total...............	13	16	29

A Case of Flagrant Malconstruction, as well as of Absurd Evidence, and Coroner's Verdict.

No. 42 Explosion, by which one man was killed and five others injured, is an illustration of bad boiler making, as well as of the unsatisfactory character of coroners' investigations with regard to these catastrophes. It occurred at half-past nine o'clock on the evening of Thursday, October 28th, at a tin works.

The boiler was externally fired, and of plain cylindrical construction, the back end being flat, and the front hemispherical. Its length, as nearly as may be, was 33 feet, and its diameter 6 feet, while the thickness of its plates was nine-sixteenths of an inch in the flat end, and half an inch in the remainder of the shell. the pressure at which it is stated to be worked being about 20lb. on the square inch. The boiler was 17 years old, but the plate at the back end had only been put in about a year.

The boiler gave way at the flat end, rending all round, or nearly so, at the root of the angle iron attaching it to the shell, when the main portion of the boiler was blown forwards, and the back end backwards for a distance of about forty yards. In addition to this, another boiler alongside was thrown from its seat, while fragments of piping and brickwork were scattered in every direction, from which, combined with the rush of steam and hot water, a man working in the mill was killed, and five others severely injured.

The cause of this explosion will already be apparent from the description just given of the form of the boiler, and the mode in which it gave way. The danger of these flat-ended boilers, unless strengthened as in those of the Lancashire or Cornish type, with flues running right through them from end to end, or else adequately stayed in other ways, has already been pointed out in previous reports, and the particulars given of a number of disastrous explosions that have occurred to such boilers from the neglect of these precautions. One such explosion was referred to, by which three persons were killed, on the 11th August, 1869; a second, by which four persons were killed and four others injured, on the 31st of May, 1869; a third, by which one person was killed, on the 27th of November, 1867; a fourth, which occurred on the 7th of November, 1867; and a fifth, by which two persons were killed and seven others injured, on the 28th of July, 1866, while others might be added to this list. The explosion under consideration was very similar to these in its cause. The flat end plate at the back of the boiler was most inadequately stayed. There were but two diagonal rods, measuring an inch and a quarter square, tying it to the sides of the shell, while these were considerably weakened at the eyes by corrosion, the metal being reduced in section to seven-eighths by seven-sixteenths of an inch, so that they afforded the back end plate no adequate support, and were easily torn away, added to which, the angle iron by which this plate was attached was not welded into an iron ring as it should have been, but was simply jump jointed, which is a most inferior mode of construction. Thus the flat end plate was altogether too weak to withstand the pressure of the steam, and was blown out in consequence, so that the explosion is by no means mysterious, but attributable solely to malconstruction of the boiler.

The evidence given at the coroner's inquest was most unsatisfactory. The first witness, who was a mechanic, and had charge of the engines at the works, stated that the boiler in question had been examined internally in the ordinary way only a week before the explosion, while he had repaired it by a screwed patch only the night before, when he examined it internally himself, and though he had examined it again since it burst he could not see anything wrong about it, and could give no reason for the explosion. This screwed patch appears to have been altogether unimportant, being only from 4 to 6 inches square and screwed by a single bolt. After him, another mechanic, who had assisted in putting on the patch, stated that he had been an engineer all his life, and having thoroughly examined the boiler the night before, and as he said, "looked everywhere," he had come to the conclusion as a "practical man" that the boiler was quite safe to work, and he was altogether unable to account for the explosion; adding that "the most scientific man if he had examined the boiler might have been deceived." The third witness, who was the out-door manager of the works, stated that the two mechanics who had examined the boiler were fully competent. He had himself had twenty years' experience with boilers, but nevertheless threw no light on the cause of the explosion. The fourth witness was another mechanic connected with the works, and who had had forty years' experience with engine work. He had examined the boiler since the explosion, but, like the previous witnesses, threw no light on the cause of the disaster. The fifth witness was a boiler maker, who had repaired the boiler in May, 1868, when, he stated, he "left it as good as new," so that "the explosion took him by surprise, and he could not account for it. He was now repairing the boiler." The sixth witness, who was another manager of the works, stated that the two mechanics who had repaired the boiler had held their position for 13 or 14 years, and that about £100 had been laid out in repairs to this boiler during the last year, but he threw no light on the cause of the explosion. After the examination of one or two other witnesses, the coroner summed up, saying that he "did not consider any further evidence necessary, inasmuch as no additional light could be thrown on the case." He thought "the cause of the explosion was a mystery, and in all probability would remain so. According to the evidence of the engineers, the explosion was clearly an accident," and he saw "no reason to doubt them. It was also clear that the boiler owners were free from blame, and had supplied proper machinery as well as efficient workmen." In conclusion he suggested that the jury should return as their verdict that "the deceased died from scalds resulting from the bursting of a boiler," but the jury found that "the deceased died from scalds occasioned by the *accidental* explosion of a boiler."

It will not pass unnoticed that not one of the witnesses referred to above was independent, but that all of them were connected with the works at which the explosion occurred, while the result of the investigation simply went to show that the boiler was immaculate, the attendance exemplary, and the death of the poor man, as well as the injuries to the five others, inscrutable and inevitable.

That such an explosion—arising, as already shown, simply from gross malconstruction of the boiler—should be styled by the coroner in his summing up as *mysterious*, and be brought in by the jury as *accidental*, is deeply to be regretted, and is fraught with the most mischievous consequences. I am informed that at the works at which this catastrophe occurred, there is another boiler of precisely similar construction to the one from which the explosion sprung, while there are many others like it employed by other steam users, so that numbers of men are working on at the hourly peril of their lives, though ignorant of their danger. Had the true cause of the explosion been brought out at the inquest, this would have been shown. As it was, no warning was given, and these deadly boilers may be worked on till other explosions occur and other men are killed. This is a most painful reflection, and I therefore felt it my duty to write to the owners of the works at which the explosion occurred, explaining the true cause of the disaster, and at the same time urging that the boiler should be at once stopped, the flat end removed and exchanged for a hemispherical one, and further that, if the ruptured boiler were to be used again, the flat end should not be restored, but a hemispherical one adopted in that case also. Nothing could more strongly show the advantage that would result from coroners being assisted, when conducting inquiries upon boiler explosions, by competent engineering advice, as recommended by this Association, than the inquisition under consideration. Had this plan been adopted on this occasion, sound information might have been generally disseminated, but as it was, the opportunity was lost.

An Explosion that might have been Prevented by Suitable Boiler Fittings.

No. 44 Explosion, by which one man was killed, was of a very simple character, and might have been prevented by suitable boiler fittings. It occured about a quarter past six o'clock on the evening of Saturday, October 30th, at a bleach works.

The boiler in this instance was of the ordinary Lancashire mill type, having two furnace tubes running through it from one end to the other in which the fires were placed. Its length was about 30 feet, its diameter in the shell 7 feet 4 inches, and in the furnace tubes 2 feet 11 inches, the thickness of the plates being three-eighths of an inch, and the load on the safety valve, as nearly as may be, 50lbs. on the square inch. This boiler was one of a series of eight, connected together both by the steam and feed pipes.

The boiler gave way in the furnace tubes over the fire, the right hand one bulging down at the crown and rending nearly half way round at the second ring seam of rivets from the from the front end, while the places gaped apart about four inches at the widest part, and thus formed an opening through which the steam and hot water rushed out, blowing open the fire-door, carrying away the hot coals, and also catching one of the firemen who was unfortunately standing at the front of the boiler at the time, and throwing him across the firing space against the wall at the back, in consequence of which he died in the course of a few hours. The boiler, however, was not moved from its seat, neither was the brickwork disturbed, nor were the joints of the steam and feed pipes broken.

There can be no doubt that this explosion arose entirely from overheating of the furnace crowns through shortness of water. The distortion of the furnace crowns gave incontestible proof of their having been overheated, while the fusible plug in the right hand furnace, though removed before the boiler was examined by the association's inspector, was stated to have been melted; added to which there was actual evidence that the water supply had been allowed to run short. It appears that the foreman boiler attendant, whose duty it was to look after the firemen and also to see that they did not neglect the water supply, had observed to one of them that there was no water in the gauge of this boiler, when the firemen replied that the glass was full up to the top, and that was why he could not see the movement of the water and had supposed it to be empty, upon which the foreman told him "to fire up, when the water would get down by wasting." It is by no means difficult to make a mistake of this sort. When the water partially fills a gauge glass it can be clearly seen, not only from the movement of the surface of the water, but from the contrast between the portion of the tube that is full and the portion which is empty; but it is difficult to tell the difference between a glass quite full and quite empty. All that is necessary, however, to meet this, is just to blow the gauge through, which all firemen know should be frequently done. This, it appears, the foreman boiler attendant was in the act of doing, and had but just discovered that the foreman had mistaken an empty glass for a full one, when the furnace crown rent, and the poor fellow was blown across the firing space, as already explained. In the interval, however, between the explosion and his death, he was able to state that, "Mick the fireman had let the water get low," and said to his wife while at the Infirmary, "Mick has done it." Had Mick taken the trouble to blow the gauge through, as he ought to have done before concluding that it was full, the explosion would not have occurred.

At the inquest, evidence in accordance with the above was given, and the coroner in summing up remarked that the explosion did not seem to be due to any defect in the quality or construction of the boiler, but solely to want of water; while, with regard to individual responsibility, the person whose duty it was to superintend the working of the boilers had paid the penalty of his neglect by the loss of his life, adding that it appeared there had been a mistake in reading the water gauge, an empty glass being taken for a full one, and therefore under the circumstances he considered there was no particular blame attaching to anyone. With this the jury agreed, and brought in a verdict accordingly.

Though this verdict is correct to a certain extent, it by no means exhausts the whole truth of the matter, and there are points with regard to this explosion which it is desirable should be brought out, in order to assist in preventing similar occurrences in future, and it would have been of considerable service had the coroner given publicity to these in his verdict.

It is important to point out that the feed was introduced by means of internal open-ended pipes, carried down nearly to the bottom of the boilers, while, though there were eight of them in the series, and all connected together, they were not fitted with any non-return or feed back pressure valves, in consequence of which all these boilers were in constant danger of having their furnace crowns laid bare, and overheated through the water in one boiler being driven out into the others, which it is very possible took place in this instance, though it does not now admit of positive proof. It is in consequence of the number of cases of this sort that occur from time to time that the recommendation, which some of the members seemed to think so unnecessary, is so frequently given the association's reports, viz., that every boiler should have its own non-return or feed back pressure valve, and that the feed inlet should not be below the level of the furnace crowns, but slightly above it, so that in case of any reflow the furnace crowns would not be laid bare. This is certainly a most simple suggestion, and is recommended to every member as a wise precaution. Again, the ruptured furnace crown was fitted with a fusible plug, which should of course have given warning of the shortness of water, but proved faithless, and as this is by no means a solitary instance, it shows how worthless fusible plugs often are. Had this boiler been fitted with a low water safety-valve, in accordance with the recommendation so frequently given in the association's monthly reports, as soon as the water disappeared from the gauge, and the fireman mistook an empty glass for a full one, the valve would have warned him of his error by allowing the steam to escape, and would not have ceased roaring until all the steam had been let off, or the water restored to its proper level. Scarcely a month passes but one or two lives are lost from explosions, which might have been prevented by the simple adoption of one of these valves.

This explosion, therefore, though it clearly resulted from the oversight of the boiler attendant, might have been prevented by due caution on the part of the owner, in having the boiler provided with suitable fittings. The best human agency will sometimes fail, and it is therefore the incumbent duty of all those who, for their own commercial advantages, avail themselves of so destructive an agent as steam is, if not rightly managed, to take advantage of every reasonable precaution to protect the lives of their workpeople. This was not done on the present occasion. If it had, the explosion and its fatal consequences would have been prevented. The coroner's investigation would have been far more valuable if these facts had been plainly stated. There is no doubt that many other lives will shortly be sacrificed through the neglect of these low water safety-valves, and hence the importance of calling public attention to this subject. Were a full investigation made on the occurrence of each explosion, and the truth plainly spoken, great good would be done, and it would be well if coroners could be aroused to see how much they could do to arrest the constant recurrence of fatal steam boiler explosions, simply by faithful investigations and plain spoken verdicts.

An Explosion from External Firing.

No. 45 Explosion occurred at a colliery, at six o'clock November 2nd, and though fortunately no one was killed, two persons were injured.

Colliery boiler explosions are of so stereotyped a character, that it hardly seemed worth while to send an officer of this Association to a distance of between 100 and 200 miles, in order to visit the scene of the catastrophe on this occasion, and I have not therefore very full information, but I have been favoured with brief particulars from a correspondent residing in the neighbourhood, from which, and other sources, it appears that the boiler, which was one of a range four, was of plain cylindrical, egg-ended construction, and externally-fired, and that it commenced to rend, as these boilers are so apt to do, at a seat of rivets near the bottom, the primary rent, which was a horizontal one, developing into others, and tearing the boiler in pieces, when the side of the engine-house near to the boilers was levelled to the ground, and the *débris* scattered right and left, the breaksman and the fireman being both injured by the rush of steam and flight of the parts. It is stated that there was an old flaw in the plates, and that the boiler had been ordered off for repairs.

This explosion is simply an additional illustration of the danger of plain cylindrical, externally-fired boilers.

THE INSTITUTION OF CIVIL ENGINEERS.

Address of Charles Blacker Vignoles, Esq., F.R.S., President.

[Although the worthy President's address extends to a most unusual length, it is so ably written and contains such a vast amount of interesting information, that we feel sure we need make no apology for inserting it *in extenso*.]

Gentlemen,—In assuming for the first time this chair, succeeding to so many distinguished and honourable pre-occupants, whose names are graven upon the marble tablet before you, the first duty is to express my deep sense of the honour, which by your kind suffrage, has been conferred, raising me to a position whereby I am called upon to preside over your proceedings, and, if it be in my power, augment the utility of our noble Institution. My second duty in point of form—though for myself I feel it to be almost paramount—is most cordially to thank my friend Mr. Hawksley especially, and the vice-presidents senior to me, who have so unselfishly waived their prior rights for a season, and led to the resolution of council to put me forward for president. To the very flattering concurrence of these friends, ratified by your most deeply appreciated vote, I am this evening placed here thus prominently. I will endeavour, gentlemen, to prove that I shall not be found wholly disqualified for fulfilling the duties you have a right to expect from me.

Let me be permitted to glance for a moment at the progress of our Institution although in doing so there must occur some unavoidable repetition of what has been expressed by former presidents on similar occasions, and is set forth in the recent annual report. It is due, however, to ourselves that our scientific brethren, in cognate professions and pursuits, as well as the engineering world outside of these walls, should be made acquainted with our success through more than one channel.

The first president of this Institution was that eminent engineer, Telford, who had but little support originally. Now, in the 53rd year of assembling, the numbers are 1632 members and associates, besides 173 students, whom we hope to incorporate with us from time to time. Well may I feel proud at being selected to preside over such an Institution.

Pondering upon what should constitute the staple of my address, I propose to limit myself to a very few subjects. I shall commence by endeavouring to interest our younger members, and I trust our older ones also, by giving a rapid sketch of the progress of events which has led to the present system on the Continent. I will next speak of our own mode of going to work. Afterwards venture upon notices of some of the chief professional subjects of the day, and if your patience is not exhausted, I will conclude with reminiscences of matters which at the time were replete with interest to engineers.

In following up this general outline I cannot engage to be very logical. I fear, also, that I shall not be able, when I come to reminiscences, to avoid allusions personal to myself. Still, amid the multifarious matter with which the speech and recollections of an old man are prone to be filled, something useful may be learned by the younger, something pleasing recalled by the elder; may I say in the words of the Latin classic—

"Indocti discant, ament meminisse periti."

Let me employ a metaphor—I hope not yet worn threadbare—and compare myself to a traveller who has ascended a mountain top towards the close of a wearisome day, and looks on the scenes passed through, spread like a map at his feet. When he first started in the morning "distance lent enchantment to the view"—Illusion vanished when reality was attained; but the scenes once left behind, the Enchantment returns partially, and, on a retrospective view, the brilliant pleasures of Hope seem to be replaced by the more sober pleasures of Memory.

In tracing the first steps of engineering, I need not refer to history for confirmation of what is self-evident, that in the earlier stages of the human race their first want must have been, as it now is, a supply of water for the men and beasts of tribes, whether nomadic or stationary, when no longer within reach of the natural streams and springs; and, assuredly, the individual who first dug a well in the desert, and raised water to the surface by the simple contrivance of pole and bucket, was the first mechanic—the first pre-historic engineer, whose rude invention, nevertheless, has been followed in all subsequent ages, introduced into most countries, and extended, by various applications of animal power, to the raising of water, wherever found, from a lower to a higher level.

As civilisation advanced, and shepherds became cultivators of the soil, in the warm climates of the East, the fertilising and renovating water was led by narrow artificial channels from the rivulet or lake, to the field and gardens. These operations, however primitive, must have required men of some experience though perhaps of not extraordinary skill.

Passing to eras less remote, we find in Egypt, at both extremes of India, and elsewhere in the East, that similar undertakings were executed on a larger scale. It is in Southern India that we first observe the additional feature of tanks.

In the Presidency of Madras there are upwards of 53,000 tanks or reservoirs for irrigation purposes alone, exclusive of small tanks near villages, all executed by the natives prior to the occcupancy of Deccan by the British. The aggregate length of the embankments of these reservoirs is fully 30,000 miles, that is, more than double the length of all the railways in the United Kingdom, and works of art which were consequent on their construction, such as bridges, culverts, sluices, &c., are more than 300,000 in number. The stored-up waters, sent forth at the proper season, still bring to the exchequer of the Madras Presidency a yearly income of a million and a half sterling (one-sixth of the whole revenue), although many of the finest of these reservoirs are in ruins, or useless from want of being properly kept up. One of them, the Ponairy Reservoir, in the district of Trichinopoly, has a superficial area of about 80 square miles, say 50,000 acres; the banks are 30 miles in extent. Another, the Veranum Reservoir has nearly 65 square miles of area, or upwards of 20,000 acres, and 10 miles of banks.

I cannot pause to speak of the ancient canals of Egypt, belived to have formed a communication between the Red Sea and the Mediterranean, and to have been maintained for six hunnred years before and about eight hundred years after the Christian era, nor of the Waterworks of Imperial Rome, or the recent discoveries relating to those of Jerusalem; yet I may mention the Bœotian Canal, said to have drained the Lake Mœris by several channels carried in tunnels through the high mountainous barriers. This canal is of such fabulous age as to have led fiction to usurp the place of history, and even of tradition, when describing the work at a period of time so far back as prior to the conquest of Greece by Rome.

The long celebrated canals of China, have in my view, been much overrated, and the romance of their unknown antiquity has vanished, since the most trustworthy representations lead to me to conclude that they are scarcely older than the works in the Deccan. At all events they date from less than nine hundred years ago, a century subsequent to the first irrigation of Valentia. In Spain, the Moors constructed canals uniting with rivers, particularly the Guadalquiver, and connecting Granada with Cadiz. They also introduced, when they conquered that country, their own system of irrigation, with the customs and laws relating thereto, which are followed at the present hour without material change.

The embankments along the shores of our metropolitan river the Thames date back certainly from the period of the Roman occupancy of this country. The struggle against the ocean maintained by the inhabitants of the countries bordering on the North Sea, began earlier, and so continues up to these days.

I come to the middle ages. Canals were introduced during the twelfth century into Italy for irrigation and inland navigation, and about the same epoch into Holland.

What I am endeavouring by these hitherto preliminary remarks is to show that in those early times it was the Government of each country that felt compelled to undertake the execution of works for public uses. Hence arose the ancient establishment of what is known in modern days as the Water Staat, as a necessity for ensuring the perfect safety of the dykes. Hence arose, also, the germ of the system in France known as the Corps des Ponts et Chaussees, of which I will endeavour to sketch the use and history.

The Romans had, of course, spread their great military roads over Ancient Gaul, though not to the same extent, comparatively, as throughout England; they shared the disastrous fate which hefel all such civilisation as existed previous to the early part of the third century. In the seventh century, under King Dagobert, what were styled the Chausses of Queen Brunehault appear to have been divided into three classes, of which first were the *Viæ Publicæ*, called at a subsequent period *Royal Roads*. It has been assumed, from tradition, that these Chaussees were perhaps partial restorations of the Roman roads; but this is doubtful, and the Capitulary of A.D. 628 refers solely to matters of police, and not to repairs.

Towards the close of the eighth century it was that Charlemagne revived what were called in his decrees the ancient laws and customs, by which the whole population of the several districts, high and low, without exception, were bound to construct bridges and roads, under the direction of the provincial counts, of whom our lord-lieutenant of a county may be taken as the modern prototype. These laws were partially enforced by the Carlovingian Successors to the monarchy up to the ninth century. The words "bridges," however, is a misnomer for the works referred to in these and former edicts; they were really only causeways across marshes and land subject to inundations, or embanked approaches to rivers, across which ferries were established. The roads, generally, fell into absolute ruin.

When the feudal anarchy was at its height, crowds of pilgrims flocked yearly to the shrines of favourite saints, and hence the establishment of fairs; then the Crusades began. Commerce, rude and peripatetic, and a faint gleam of civilisation forced attention to the state of the roads in the course of the twelfth century; but the want of bridges was felt to be a still greater evil, and called for prior remedy. Then it was that to build a bridge was deemed a work of charity, and large properties were dedicated in perpetuity to such pious purposes of which we have several instances in this country—notably the estates whose, revenues are still appropriated to the upholding of Rochester-bridge, across the river Medway, and were applied to its reconstruction, effected little more than twenty years ago by Sir William Cubitt.

About the above mentioned epoch was formed the celebrated Monastic Order of Bridge Builders. The recognised title of a Monk Engineer of this order was, in the barbarous Latin of the middle ages, Pontifex (Constructeur de Ponts) bridge builder.

This monkish order of bridge builders, which I shall not hesitate to characterise as the first Institution of Civil Engineers, continued almost uninterruptedly for several hundred years; it is not certain whether they were quite separate from others, their purely ecclesiastical brethren, but they were a mendicant order, solely, however, to raise sufficient funds for bridges. History records few of the names of these pious engineers, but the last was the monk *Romain*, who, after long previous good service under Colbert, became one of the first of the engineers in the Corps de Ponts et Chaussees of France.

I cannot hope to find time for more than mention of the system of *Corvée*, or forced labour on roads and bridges, which we find existing in the seventh century, then disappearing, or nearly so, until revived by Louis XIV., and continued, with all its evils, until 1790, the epoch of the French Revolution. We have traces of the *Corvée* in what is called "Statute Labour," and "Parish Road Rates;" and I believe it is is still in usage, unless recently abolished, in some of the Channel Islands.

I must remark that when the success of canals in the Low Countries drew the attention of Europe, a sort of mania arose in France for inland navigation. Most of these were rendered abortive, and became abandoned, from uncertainty in the supplies of water on account of irregular rainfall, and from the pre-existing monopolies of the millers, who appear, at all times and places, to have been, as they still are, the natural enemies and thorns in the sides of the hydraulic engineer. Navigation on the upper branches of rivers rapidly ceased, but concessions for canals in France were then given. The Canal de Briare was the earliest, and next the Languedoc canal, though neither was finished until about forty years after their first imperfect commencement. So early as the twelfth century, as I have already stated, large canals had been cut in Flanders, though the great canal from Brussels to the Scheldt was not completed until 1560, still a century before Louis XIV. had finished the earliest of those in France.

It was Louis XI. who first established posthouses and relays of horses along certain chief roads. In 1550 the first road guide book for France was published describing about one hundred routes. In 1556 a regular Chaussèe from Paris to Orleans was made; but, for more than a century later, the great highways (and for these only had any repairs been hitherto undertaken) were only suited for the rapid transit of horsemen, though wagons, or other covered or uncovered vehicles, like the Araba of Eastern countries, or the Tarantass of Russia, travelled in good weather over the wild tracks. It was in 1660 that the celebrated statesman Colbert was appointed by Louis XIV. comptroller general of finance, and for many years exercised powerful and efficient rule over all the ways of communication, employing independent architects and engineers, civil and military, most of whom he appears to have mistrusted, and paid all badly and irregularly. Much of their time, and large sums, were devoted to keeping passable the chief routes from Paris to the seats of war for the passage of the Grand Monarque to enjoy the triumphs gained for him by his armies.

At the death of Louis XIV., after several abortive attempts, the charge of the internal communications was taken out of the hands of the Fiscal Department, and the decree of the 1st of February, 1716, marked the date of the actual establishment and definite organisation of the Corps des Ponts et Chaussèes; a hierarchy of engineers was then created, which, though the duties first attributed to them have since been vastly extended, still exists in its leading features.

As now constituted, this Corps des Ponts et Chaussèes forms the most important branch of the Government department in France, designated as the "Ministry of Agriculture Commerce, and Public Works." It is impossible in a brief sketch, such as I am attempting, to give more than a faint idea of the importance and many ramifications of this Ministry, which includes the direction, inspection, and in many cases the carrying out of what, in this country, are assigned to various and generally independent bodies, or are not looked after at all, at least systematically.

The engineering branch inspects and controls every railway, canal, and navigable river, whether completed and in operation or only in progress. It brings every mill and manufacturing establishment, worked either by water or by steam, under its direction; mines, sunk or open, beds of minerals, quarries, and collieries, come under its regulations, and of course, all steam engines, stationary or locomotive. Also all establishments for electric telegraphs, water, or sewerage, and the streets and improvement of towns. A special office is devoted to the management of all the lighthouses, channels, and buoys on the coasts, estuaries, and harbours. The construction and repair of highways and carriageable roads, of every class come under its control. Further, it establishes the minute regulations for the preparation, on fixed scales, of every plan and section intended for the purpose of soliciting a concession, and for every stage of the works subsequently executed.

Thus this Ministry combines in itself, and becomes, theoretically, responsible for many of the duties performed in this country by the "Standing Order," and other committees of both Houses of Parliament, by some department or other of the Board of Trade, the Custom House, the Ordnance Survey Office, the Hydrographical Branch of the Admiralty, the Trinity Board, the Woods and Forests, the Board of Health, and other public Boards and Commissioners, by the county, city, and borough surveyors, by the way wardens, and by innumerable local officers throughout the United Kingdom; besides many other duties and functions which in this country we have had no thought of creating for the purpose of control, but which are vested in this Ministry by their perfect system of centralisation.

To keep this enormous machine in good working order the subdivision of labour and responsibility has been carried to an extent, which is a striking proof of the organising faculties of the French. There are in Paris about thirty-two bureaux, each with its staff of chief, deputy, and clerks, of which fully one-half have their attention devoted exclusively to public works. So of the almost as many permanent commissions sitting in Paris.

For the public works the corps has 877 engineers in eight classes, of which 134 belong to the division of mines, and 4343 conductors, in five classes, of which 149 are mining guards. In addition, there are 275 harbour masters and other port officers. In the whole, 5,495 employés, at the present time nominally available, and 150 officers are invalided with retiring allowances, there being nearly 200 widows of deceased officers in receipt of pensions. The Ecole des Ponts et Chaussées has 15 professors, mostly from the corps, 8 teachers, and 30 other persons on the staff for regulation purposes; at present, however, there are only 55 pupils at the school. The Ecole des Mines has 16 professors (mostly engineers), 8 teachers, and a large staff besides. There are only 9 pupils. The two working mining schools, at St. Etienne and at St. Alais, have 13 professors and teachers. We have often heard of the admirable modern management of the streets of Paris. To effect this, there are specially appointed 16 engineers of all classes, and 152 conductors, who have charge of the public streets, roads, foot pavements, promenades, plantations, water supplies, and sewerage, all appointed by the minister, but paid for by the Mnnicipality of Paris. I am not now considering the cost, but merely the organisation, which is certainly most complete and effective in its results.

The late Mr. Hosking, Professor of Engineering and Architecture at King's College, laid it down as a maxim, that it is "the combination of the workman and the man of science that forms the civil engineer," and I adopt the definition, as we all must. But the engineer of the Corps des Ponts et Chaussées is a highly educated scientific gentleman, and, as our esteemed member, Mr. Calcott Reilly, said in debate a few weeks since, and there can be no better judge, "These engineers are all mathematicians." No doubt; but very few probably are at first practical men. These are found in the class of Conducteurs des Travaux et Gardes-Mines, and the young engineers are usually wise enough, till they acquire thir own experience, to rely on them, they being generally really workmen.

These conductors of the Corps des Ponts et Chaussées are a most valuable, and in the main, trustworthy body. They are entered, first, into the lowest of the six classes into which they are divided, at the average age of about 25, after having served an apprenticeship to some master workmen. By the time they are 50, they get to rank as principal conductors, and after a further service in that rank, varying from 3 to 13 years, they obtain appointments as sub-engineers, but rise no further for want of sufficient previous education; they may be considered as the corporals, sergeants, and sergeant-majors of the corps.

Those of higher grade (the commissioned officers, as it were, of the corps) enter the Ecole des Ponts et Chaussées at about 21, and at the end of 3, 4, or 5 years are usually qualified for, and pass their examination, being then appointed as ordinary engineers of the third class, at which period they are not far from 25. They then rise through all the ranks of the hierarchy, until they obtain the position of inspector general of the first class (the highest grade) after a service of 36 years, on the average. I have not been able to ascertain the rules of promotion, but I infer that the promotion is not altogether by seniority. Neither can I get any reliable information about their pay, except that the first 40 engineers in chief of the first class, each having served about 35 years in the corps, on the average, appeared to be entitled (under what circumstances I know not) to a salary of £320 a year.

Such are the arrangements in the celebrated Corps de Ponts et Chausseos of France. In theory the system is perfect, but it drags along terribly slow according to our ideas—and we must come to the conclusion that however powerful to control, it is ill adapted to originate

This complete organisation in the ministry of public works is kept by the strictest supervision. Among other regulations, is the preparation annually of a volume or directory of five hundred closely printed pages, chiefly tabular—bulky as the annual list of our army. It is interesting to turn over the leaves, and I shall place in the library a copy of the last publication for 1869, by way of voucher for the analysis I have given you; but there is no record of works executed, except occasional and voluntary contributions from engineers to a separate official publication by the department, entitled the *Annals* of the corps, commenced about forty years ago, and still regularly continued. These annals contain papers of the same character as those which appear in our own printed minutes; but they set forth, in addition, every decree and ministerial decision upon points of engineering practice; especially in the working of the conditions in concessions granted. These can only be compared to a collection of reported law cases on these subjects, which, in fact, they really chiefly are.

This system of interference and control in all matters of engineering has been adopted more or less stringently by every Government in Europe. It has been introduced into most of the States in South America. I have had to encounter it in France, Spain, Switzerland, Holland, North and South Germany, Russia, Austria, and Italy, and in its most annoying and most mischievous form in Brazil.

Turning to the engineering of this country, the leading principle is, that except in a very few limited cases, the Government does nothing, recommends nothing. Everything is left to be accomplished by individuals and associations, and then the rule is to interfere as little as possible. The practical result, however, is that wondrous improvements have been effected to a vast extent and in every direction.

Private, or as they are popularly called, public companies, associated in devising improvements for local benefit, were not much known, perhaps I should rather say not appreciated, in England, before Sir Hugh Myddleton had directed the springs of St. Chad at Ware and Amwell into London, and the Duke of Bedford had brought Dutch engineers to drain the Fen country; though it is known and must not be forgotten, that just previous to the alarm raised by the Spanish Armaea, Sir Walter Raleigh was engaged in a survey for bringing water from Dartmoor to Plymouth; still, what we now call private enterprise did not thrive generallv till very mnch later; and it was not till the beginning of the second half of the last century that the tide of wealth began to turn towards effecting internal improvements.

Although the proprietors in what was called the "Old Quay Company" had obtained an Act of Parliament in 1733, for improving by weirs and cuts the rivers Mersey and Irwell, between Runcorn and Manchester, the first association incorporated for making a regular navigable canal in England was not till more than twenty years later, viz., in 1,755 utilising the Sankey Brook, in Lancashire, and finished in 1,760, six centuries after the first canals in Italy and Flanders, and a hundred years subsequent to the canals of France being in operation. In 1,758 the celebrated Duke of Bridgwater got his first Act of Parliament, and says a popular writer of the past century, "then was awakened a general ardour for similar improvements among the land-owners, farmers, merchants, and manufacturers of the kingdom, and although there was not a Louis XIV., nor a Colbert to encourage them, there wanted not engineers equal to Riquet; and England, though late, began to rouse from her lethargic slumber, and pour forth the riches she possessed in her inland provinces."

The rage for making canals became almost as great as ever was the subsequent mania for railways; this continued during nearly forty years, in which time the greater number of our canals were cut, though their construction was pursued, less ardently, for 30 years longer. The aggregate length of our canals is now about 3,000 miles, against 3,154 miles in France, exclusive in both countries of inland navigation by rivers.

About the same period in the last century with the introduction of canals, the attention of all classes of the community was directed to the state of the high ways. Bills for making turnpike roads were passed every year to an extent which seems almost incredible, and in addition every parish was compelled by the force of public opinion, supplemented by indictments aud fines, to improve their ways; this pressure acting through more than a century, has resulted in our having in the United Kingdom a network of fully 160,000 miles of good carriageable roads, France having at this very day barely 100,000 miles of such roads of all classes. I say nothing of the wonderful improvements and embellishments of every town and suburb in the empire. Thus much for private energy and self-reliance as against centralisation. I may add that the proportionate superficial areas of France and of the United Kingdom are as 12 to 7.

I cannot here refrain from a momentary interruption to express my astonishment at the state of the roads in India. In the Bengal district only, which has an area exceeding 250,000 square miles, or much more than double that of the United Kingdom, there are (should the statistics which I have seen be correct, and I know no cause for doubting them) over that immense district only 1,869 miles of metalled roads, 6,064 unmetalled, and 5,815 unmetalled and unbridged, which last are described in an official report as "mere *trac s*, passable in the dry season only." And this district is stated to have a population of forty millions of people, paying one third of the revenue of India. In one province only (Patna), where cultivation has wrought beneficial changes there are reported to exist three or four miles of road to every twenty square miles of country; but in the rest of the Bengal district there is only one mile of *track* to twenty square miles of territory. In this country there are twenty six miles of good roads within the same area; in France as yet, only ten miles.

The perfection to which travelling over our roads was brought thirty-five years ago, cannot be appreciated by the majority of those whom I have the honour of addressing, except from what they may have read, or learned from their older friends. Men were then begining to value time, and when the grand career of improvement culminated in the introduction of railways, as a substitute for mail coaches and posting, they soon acknowledged what is now a mere truism—that distances are virtually shortened in the precise ratio in which the time occupied in traversing them is abridged.

I proceed to take a rapid view of the most interesting engineering matters of the present day, abroad as well as at home, though but a very few paragraphs can be devoted to any one subject, as there are many; and my list has not been made out very systematically.

Amsterdam Sea Canal.

The Amsterdam Sea Canal, designed by, and now in course of execution under the direction of our Past-President, Mr. Hawkshaw, and Heer J. Dirks, of Holland, is a gigantic example of engineering compressed within a limited extent. The burgesses of Amsterdam had spent millions in improving the access to that great commercial port; first by long previous operations in the Zuyder Zee, and subsequently on the North-Holland ship canal, which stretches nearly due north for about 52 miles, from their city to the Helder, between which point and the Texel island opposite, is the entrance from the North Sea, and at present the only available channel for large vessels.

The exigencies of their trade calling imperatively for further improvements, the engineers furnished them with the design for a new ship canal, which reduces the navigable distances to 15½ miles, on a course about west from Amsterdam to the North Sea, available for larger vessels than now come up to the port, and providing a new harbour on the coast, to have an area of 250 acres, bounded by breakwaters formed of concrete blocks, set in regular courses, with 853ft. of entrance between the pier heads and 26¼ft. minimnm depth of water. The width of the Sea Canal is 197ft. at the surface, 88ft. at the bottom, minimum depth 23ft; locks 59ft. wide, and of proportionate length.

There will be three locks or entrances at the west end of the canal from the new harbour. Eastward, and below the city and wharves of Amsterdam, there will be a mighty dyke to shut out the Zuyder Zee, pierced with three locks, besides sluices; these have to be built upon such a lake of mud as to require nearly 10,000 piles in their foundation. Thus the canal will be approached by locks at each end, not for the purpose of locking up, but for locking down, as the surface water of the canal has to be kept 20in. under low-water mark. To accomplish this, in addition to the locks and sluices, that can only avail at low tides, pumping power is required at the dyke, which bars out the Zuyder Zee. The three large centrifugal pumps by Messrs. Eastons, Amos and Anderson, already delivered though not yet in operation, will together lift 440,000 gallons of water per minute.

The lakes through which the canal runs are to be re-drained to admit of this; branch canals have to be cut to the several towns and ports on the borders of the lakes. These branches, though of smaller sectional area exceed the sea canal in length in their aggregate extent. The works have already been three years in progress, and it will require six years more to complete them. In some respects this Amsterdam sea canal may be said to resemble the Suez Canal, so far that it passes through two large shallow lakes, having the same depth of water, and the same muddy substratum as the lake Menzaleh in Egypt, and then running through a deep sand cutting to the sea, with a barbour, as at Port Said.

Tower Sub-way

This remarkable work has excited much attention, from the small cost and the rapidity with which it has been executed. It was designed by our member the senior Mr. Peter Barlow, F.R.S., and carried into completion by his son. The intention of the designer was not only as a mode of communication, by omnibus, under the Thames and other large rivers, but to illustrate a system which, Mr. Barlow contends, is alone capable of relieving the street traffic of the metropolis. The Tower Sub-way may be briefly described as consisting of two vertical shafts, one on Tower-hill, and the other on the opposite side of the river, adjacent to Tooley-street, in the Borough, each of 10ft. internal diameter and about 60ft. deep, penetrating well into the London clay, these shafts being connected by a circular tube, or tunnel, of 7ft. clear diameter, and 1,350ft. in length, which dips from the bottom of one shaft far below the bed of the Thames, and rises again to meet the other shaft, resembling in longitudinal section, a long curve, of which the ends are on a gradient of 1 in 40.

Passengers will be conveyed up and down the vertical shafts within circular lifts, having suitable breaks, and worked by steam power. These lifts resemble those used in the large modern hotels, but on a greater scale, and they will hold comfortably, as many persons at a time as will fill a roomy omnibus, which will wait at the bottom of the shaft, for the descending passengers. The transit of the omnibus between the bottoms of the two shafts moving along a permanent single line of railway might be effected by gravitation, giving sufficient velocity on the descent to ascend the opposite plane, aided, if necessary, by a power not exceeding that of two men; but I am informed that it has been determined to employ small donkey engines with a wire rope, and a propelling power of about 100lbs. In either case the transit of the omnibus with the passengers will only occupy one minute. In this way between 3,000 and 4,000 persons can be conveyed between Tower-hill and Tooley-street daily, at a charge of one penny only.

The lift engines will be below, so that the only permanent occupation of any part of the ground will be the lift-house on the top of the shafts, which does not cover the space of an omnibus, thus with scarcely any perceptible occupation of the surface, large streams of traffic may be conveyed under the streets. Without going into details, it may be stated, that the tunnel and shafts are now completed, and are so perfectly dry that the question of getting rid of the dust will be more important than that of getting away the water. During the whole time of execution, the necessary water, even for drinking, had to be sent down to the workmen by the shafts. The rapidity of execution is to be explained by the tube-tunnel being of cast iron, propelled by using a shield forced forward by powerful screws, and overlapping the tube, like the covering to the object-glass of a large telescope.

The contractor had the land on Tower-hill placed in his possession on the 12th February, 1869. The Tube-tunnel was driven as far as high-water mark on the Middlesex side by May 26th, and reached high-water mark on the Surrey side September 8th; the length under the Thames, 890ft., having been finished in fifteen weeks. The land for the Surrey shaft was handed over to the contractor October 5th, and before Christmas the shaft and tunnel were completed. The only work remaining to be done is the fixing of the lifts, for raising and lowering the passengers. The whole expenditure to the end of 1869 has been £14,500, and when all is finished, the outlay will have been £18,000.

Bermuda Dock.

One of the most interesting operations during the past year was the voyage of the huge iron "camel," known as the "Bermuda Dock," 4,000 miles across the Atlantic Ocean from Sheerness to Bermuda, the most important station of the North America and West India command. A dock capable of receiving large vessels of war had long been an absolute necessity there; but the intention of constructing a stone dock was abandoned for various practical and indisputable reasons; it was therefore determined by our scientific associate and member of council, Colonel Clarke, of the Royal Engineers, Director of engineering works to the Admiralty, to adopt a floating dock as peculiarly suited to the situation, which was designed and built by Mr. Campbell. I have called this "Bermuda Dock" by the name of "Camel," long ago taken into our engineering vocabulary from the name of the original vessel and its fortuitous destination and temporary contrivances, the history of which is remarkable.

A sheer-hulk with the ends taken out gives a rough idea of the—vessel, shall I call it?—but with hollow sides and bottom, each fully 20ft. wide, with all the interior of the hulk removed, leaving a cove, shaped to the form of the hull of a large vessel, 330ft. long and 54ft. wide, as the future dock; the dimensions over all being, length 381ft., breadth 124ft., depth 74ft. I cannot pretend to give any details, but the construction is of wrought iron, about ½in. thick on the average throughout, and divided into numerous water-tight and air-tight compartments. The weight of iron material in the dock is about 8,200 tons, besides 400 tons in the caissons, sent out separately and put together at the island.

The "Bermuda Dock" is capable, without the caissons, of taking in any vessel now afloat with the exception of the "Great Eastern," whose width is too great to admit of her entrance. Our largest ironclads, having a displacement of 10,200 tons, can be lifted by her so as to have their keel out of water. Two peculiar advantages are, 1st., that the dock using her caissons, will lift and lay completely dry a vessel weighing 8,000 tons, raising the docked ship only 14ft., with the consequent less exposure to wind, than if she were lifted 28 or 30ft., which would be necessary were no caissons employed; 2nd., by this mode of construction and her shape, which assimilates to that of a ship, the "dock" can be heeled over so as to enable her to be thoroughly overhauled and cleaned from fouling. This operation was performed twice at Sheerness before her start, and on each occasion was accomplished in two days and a half, one side being cleansed at a time.

The building of the "Bermuda Dock" occupied two years up to her being launched, and nine months more for entire completion. The draught of water, light, is 11ft. 2in., and 50ft. when submerged for docking a large ironclad. The "dock" was towed out by two of the largest steamers of the navy, with a third astern for steering, and several small look-out steamers. The voyage occupied thirty-six days. The average speed was little more than 4½ miles an hour. Much experience was gained on the voyage to be hereafter available. While the executive officers connected with the expedition richly deserve their meed of praise for the care and skill with which the onerous duty was performed, the highest credit is due to Colonel Clarke for having formed the bold scheme of transporting the "Bermuda Dock" across the Atlantic by towing, and for the steady determination with which he adhered to his plan, and maintained that it was feasible, in the face of the discouraging and adverse opinions which it elicited. I am indebted for this information about the "Bermuda Dock" to the book by Capt. Webb, just published, which is of the highest interest, and worthy of perusal.

Engineering Works of recent date in North Germany.

The first dock-harbour on the German coast was Bremerhaven, for the city of Bremen, at the mouth of the Weser. A rival port called Gerstemunde, is now in the immediate vicinity. The double-gated entrance dock has a width of 80 feet at the gates; length of chamber, 250 feet; depth on the sill 24 feet at high-water, or 13¾ feet at low-water; dock area, 16¾ acres; but room for great extension. Quays, sheds, and warehouses are provided. The gates are curved, and of wrought iron.

A larger work is the Prussian Royal Dockyard Wilhelmshaven, on the Jade. The works were begun in 1857, and are nearly completed. Outer basin (tidal) about 700 feet long; width of entrance, between pier-heads 220 feet. Piers of masonry on concrete foundation. A pair of lock-gates admit to a basin or chamber of 600 feet by 400 feet, closed at the inner end by another pair of gates of the same dimensions. Depth on the sills 28½ feet at high-water or 16¼ feet at low-water. Dock area inside of inner gates 32 acres. Two dry docks, 450 feet long, are completed; a third one of 880 feet is in progress. Other accommodation if fully provided. The solemn inauguration by the king, personally, took place 17th June, 1869.

Another Prussian Royal Dockyard is in course of being built on the Baltic coast, in that excellent natural port Kiel. Slips, dry docks, quays, and other accommodation are in execution on a large scale, begun in 1869.

A work to be noticed likewise is the new Steam Quay at Hamburg. It is tidal, but provided with sufficient depth for commercial steamers to float along the quay-side at low-water. In 1868, 2,600 feet of length were in operation, provided with 19 steam cranes, sheds, and railway communication. The steamers are generally unloaded and re-loaded within from three to four days; in cases of emergency, twenty-four hours suffice for both operations. The tonnage accommodation per lineal foot of quay, per annum, is stated to be 161 tons, which, I think, is more than double that usually taken as the average for Liverpool.

The Prussian commercial ports on the Baltic are to be improved by the introduction of the principle (long ago adopted in England and France) of piers with steep, nearly perpendicular or curvilinear sides, built of masonry from low-water upwards, with occasional use of artificial blocks of concrete. The old-fashioned, dangerous, flat-sloped jetties of loose stonework are thus improved to a great extent at Swinemunde (Stettin), and, on a small scale, at Pillau (Konigsberg). At Stolpmunde, an outer basin of 10 acres has been formed in front of the old harbour, by two new piers carried into the sea, and constructed on the new principle.

As projects of importance in Northern Germany may be mentioned:—1st, the Great Canal from the North Sea, near the mouth of the Elbe, to the port of Kiel on the Baltic. The plans are fully prepared, and the works estimated at about five millions of pounds sterling. 2nd, A New Port of Commerce and Refuge on the Western Coast of Sleswig, where the island of Rom is to be connected by an embankment of about three miles long, with the coast, the port on the island being thus brought into communication with the continental railway system. This harbour is expected, to be the most accessible port on the German coast under all circumstances of wind and weather. The works are estimated at about three-quarters of of a million pounds sterling.

Still greatly wanted is the completion of the lighting of the German Coast, there being several great distances of darkness near the coasts of the North Sea (between the lights of Borkham and Heligoland, and between those of Heligoland and Sylt), as well as on the Baltic coasts. The enlightened Government of Prussia, by which already in many cases light has been thrown in dark places, will no doubt here also find ways and means for remedy.

Four or five new crossings of the River Elbe by railways are at present in execution, and may be mentioned :—1st, the crossing between Hamburg and Harburg (first proposed in 1833, again in 1855) in the direct line from Paris, via Venloo, Bremen, Hamburg, to the East (Petersburg). 2nd, at Hamerten (a small village) in a new, direct (almost straight) line from Berlin to Hanover (Cologne). 3rd, at Magdeburg, where the fortifications are being dismantled for enlarging the town and finding room for a central railway station, whereby the present most intolerable station, the worst in Europe, will be disposed of. 4th, at Torgau, on a new line, Halle-Sorau-Guben. A fifth one, at Zomitz, will be commenced in 1870, rectification of the Hamburg-Berlin railway. The new great bridges will all be constructed of wrought iron; the piers of masonry, some of them founded by pneumatic apparatus. Descriptions of the same are not yet published.

An observation of a more general character presents itself obviously on this occasion. It is a well-known fact that Germany has been suffering long for want of a central power, strong enough to defend the national interest against the selfishness of a number of small independent governments. The German railway lines prove this by numerous deviations where common sense and national spirit would at once have chosen a shorter and a better line. A remarkable change for the better has taken place since. Under the guidance of the Prussian government, the North German Confederation has had to decide the national questions among which, very wisely, the constitution names railways. The consequence is, that where hitherto the traffic has been dragged round along polygons, at present the diagonals are aimed at, many of which have long before been proposed in vain by enlightened people.

The instance between the two great commercial ports, Hamburg and Bremen, is striking. The present railway distance between these two cities (in consequence of the obstinacy of the late Hanoverian government) is not less than 190 English miles; the length of the turnpike-road being only 64 miles; which will also be about the new railway distance when the direct line shall have been opened.

Armour Plates and Military Engineering.

While science applied to the military art has, on the one hand, aided in the production of weapons whose powers are marvellous, it has, on the other hand, in its application to military engineering, solved the difficult problem of obtaining practically for our coast defences invulnerability to the penetration of their projectiles; and that, too, in a manner more economical than was once hoped for. It had long been felt that to iron we must look for obtaining the necessary resistances to the great penetrative powers of modern ordnance, but, till recently, some erroneous impressions prevailed with regard to the ratio of the powers of resistance of wrought iron. The theory which once obtained amongst military authorities, that the resistances of wrought iron plates were proportionate to the squares of their thicknesses, was rudely dispelled by the experiments of last year, at Shoeburyness, which showed two 5in. plates bolted together to be equal in resistance to a solid 10-in. plate, while three 5-inch plates gave better results than solid 15-inch plates.

Great efforts had been made in the manufacture of iron plates to obtain them in solid masses of the full thickness deemed necessary to resist penetration. This was owing to an idea, now exploded, that compound structures of iron and other materials could not be devised to resist the shearing and shattering effects of heavy projectiles; the difficulties, however, have been overcome by our military engineers, and the forts guarding the vital points on our coast will now be protected by compound structures of iron plates and iron concrete, ingeniously held together by systems of fastenings which experiments have proved to be able to resist successfully the collateral shearing and racking effects which high forces of impact induce.

While investigating the problem of protecting the ponderous guns with which our forts are armed, the question of working them by ingenious mechanical appliances has not been neglected by the military engineer; and whereas it is but a short period since simple levers of the first order were almost the only mechanical aids to human power which were used in working guns, at the present time a system has been elaborated by which not only will the heaviest guns be trained and pointed with the ease of toy weapons by means of hydraulic power, but the supply of the ammunition, from the magazines and stores to the very muzzle of the gun, can also be effected by similar means.

The excessive forces and strains induced by the explosion of the large powder charges used with heavy ordnance, and acting destructively upon the structures which support them, have been neutralised or taken advantage of by mechanical devices of the highest ingenuity, the recoils have been controlled by elaborate compressors and hydraulic buffers, while in the case of Captain Moncrieff's carriage a portion of the recoil is usefully absorbed in lowering the gun under cover. Notwithstanding that the strains I allude to are incomparably more severe than any dealt with but a few years back, yet engineering skill has so far mastered them that the traditional fixed platform can, when necessary, be replaced by moveable platforms, such as turntables, to facilitate the training of monster weapons The old system of balancing them upon the supports at the trunnions and the breech is likewise proposed to be abandoned for a system of muzzle-pivoting, whereby the exposed surface presented by the ports, through which the guns fire, will be reduced to a minimum.

This retrospect of the progress made in the art of military engineering in the recent past would be incomplete without a reference, however brief, to the complete subjection of electric forces to improvements in defences and in the art of war. The application of electricity to submarine mining has been so successful, that a new adjunct to defensive war is obtained, while its application to military signalling ensures that mainteuance of communication between the scattered divisions of an army, by which alone the harmonious working of the whole can be attained. The importance of this subject, as well as of submarine mining, was very apparent in the late War of Secession in America; but the value of military signalling was only fully realised in the recent struggle between Austria and Prussia; since then, both submarine mining and military signalling have been reduced to system, and form an essential branch of education at the school of military engineering at Chatham.

Rifled Ordnance.

It appears that there has been no increase in the actual power of the Ordnance service-gun within the last year. Then, as now, the Government factories stood in actual construction at the limit of 25 tons weight, and 12in. calibre; but it is stated that guns of 30 tons have been ordered, and guns of 50 tons designed. I understand, however, that the principle adopted by the Ordnance authorities is that nothing beyond a 25-ton gun is called for by the thickness of armour borne by foreign vessels of war, and that, as far as known, no foreign power possesses a more powerful gun. If this be the doctrine really held, I venture, not *ex cathedrâ*, but on my own personal judgment, to demur to the validity of the reason, notwithstanding that the few American guns of 50 tons weight, smooth-bored and of cast iron, were proved inefficient compared with rifled guns, by the fire from a 15-inch smooth-bored gun, against an iron structure representing the fort on Plymouth breakwater. This was at Shoeburyness, in June, 1868. The greatest effect produced by the spherical shot with a charge equal to 100lbs. of American powder, was a large circular indentation between 4in. and 5in. deep; indeed, the American Secretary of War has acknowledged that we are better prepared than they are, and it may be well conceived that with this conviction, his countrymen will not rest till they at least equal, if they cannot surpass us.

It is considered by the Ordnance authorities that if guns of 30 tons, or even greater power, should be made hereafter, it will be chiefly to utilise to the utmost the mechanical facilities for their action afforded by the turret principle in naval construction. If the turret ships *Devastation* and *Thunderer* are each to have four guns of 30 tons or more, as is believed, they will be the first to demonstrate more than one mooted point on this subject.

It seems that our Government have now 1,200 of what are termed armour-piercing rifled guns, from the 7-in. to the 12-in. calibre, of which 500 are 12 tons and upwards, the 12-ton gun has been subject to severe trials for strength and endurance. The 25-ton gun has as yet fired only 100 battery charges.

An important investigation in gunnery now going on relates not to guns, but to gunpowder: it is directed to the discovery of the actual law and exact measure of the force exerted by fired gunpowder in a tube. Sir W. Armstrong in his address at Newcastle to the Institution of Mechanical Engineers, in August, 1869, alluded to this subject as follows:—"The action of expanding gas in a gun is analagous to that of expanding steam in the cylinder of a steam engine; and we all know the advantage in the case of steam, of having a high pressure to begin with, provided a steam jacket be used to maintain the material of the cylinder at a temperature equal to that of the entering steam. But in a gun we can have no provision analogous to the steam jacket, and it would appear that it is owing to the necessary absence of such a provision that there is a limit to the increase of initial pressure, beyond which no gain of propelling force is realised. Perhaps I shall not be fully understood without explaining this curious and important subject in a more definite manner, and I will therefore endeavour to do so. The force exerted in a gun bears a certain relation to the heat evolved by the gasification of the charge. The greater the heat the greater the force, for heat is nothing more than unexpended force. I have already alluded to the loss of heat by transmission to the gun, and it is evident that this transmission must be greatest in amount when the heat of the gas is highest. By using a slower burning powder less heat and pressure are evolved at first, and the waste of heat in the stage of initial pressure being less, more heat remains for expansive action. Hence the slower burning powder is weaker at first, but stronger afterwards; and although the quantity of gas be only the same and the pressure not so great at any point, yet the aggregate pressure throughout the bore may equal that of the more energetic and more dangerous power. This would not be so if the gun, like the steam-jacketed cylinder, could be maintained at the maximum temperature of the elastic medium within, but, in the case of the gun, that temperature would be far above the melting point of its own material. It is only lately that attention has been strongly directed to the powder question in England. In Russia and Prussia, where great efforts have been made to obtain endurance with large rifled guns, powder similar in granulated form to that used in England has long been wholly discarded, and superseded by powder stamped into prismatic blocks, which burn more slowly; but although we have erred in using a powder for our new ordnance so violent as to be justly designated 'brutal' by the French, yet we have this satisfaction, that the ordeal which our guns have sustained with our severer powder affords an assurance of strength which we could not have had if they had only withstood the mild description of powder with which alone continental guns have been successfully tried. Attention is now fully awakened to the subject, and a scientific military committee is conducting experiments upon the force of different descriptions of powder. In these experiments, the pressures exerted in every part of the gun are determined by the use of an instrument of exquisite delicacy, invented by my friend and partner, Captain Andrew Noble. This instrument, which is a happy combination of mechanical and electrical action, indicates the velocity attained by the projectile at any number of points in the gun, and from these velocities the pressures are deduced by calculation. Thus a diagram of pressure can now be exhibited for gas in a gun, as well as for steam in a cylinder, and I think you will agree with me in regarding the result as no small triumph of mechanical science."

Since that time the inquiry has grown in interest at every stage. It would be anticipating results not yet made public to say more than that the application of actual measurement to the velocity of translation of a shot in the bore of an 8-inch gun has shown that different descriptions of gunpowder differ 34 per cent. in their disruptive effects, without showing any corresponding difference in the *vis viva* of the shot when it leaves the muzzle. Where British large-grained rifle powder produces a pressure in the bore of 23·2 tons per square inch, or nearly 3,500 atmospheres, 17·3 tons only, and even less, or upwards of 900 atmospheres lower, has been obtained from other descriptions of powder.

Here, however, it is but the barest justice I should mention that four or five years ago Captain Wynants, of the Belgian corps of Royal Engineers, published a pamphlet on this subject, strongly recommending coarser powder and slower combustion for rifled cannon; and I had the pleasure of introducing that officer to the Ordnance Committee, who heard his explanations; but I believe nothing resulted therefrom.

It is deeply to be lamented that a certain amount of antagonistic feeling appears to exist between those who regard the present Ordnance service-gun with favour, and those who put their faith in our esteemed member, Sir Joseph Whitworth, and the merits of his rifled ordnance. The ordnance authorities, on the one hand, appear to hesitate adopting, or, at least, trying what I am to understand the Admiralty authorities, on the other hand, have determined to give a fair trial to, namely, the 35-ton gun on the Whitworth rifled system with elongated shot. If this intention be realised, there will be an excellent opportunity of a fair trial, on what I conceive to be correct principles, stated thus:—

The value of a rifle-gun may be properly estimated by the lowness of its trajectory and the length of its shell. To obtain these two important elements in the greatest degree, it is requisite that the gun should consume a column of powder not less than three diameters in length, and without producing a permanent alteration in the diameter of its bore by the explosion. The power of hitting objects at unknown distances depends greatly on the lowness of the trajectory. At very short distances a shorter shell may give a somewhat lower trajectory than at longer ones.

But for destructive effect at very short distances, Sir Joseph Whitworth clearly showed in the paper he read on the penetration of armour plates, at the meeting of the British Association at Exeter, that shells twice the ordinary length gave the greatest penetration, while they contained double the ordinary bursting charge.

It is highly desirable that there should be some fixed standard of length of range, at which all guns should be fired. If such standard of length were adopted, the merits of guns and ammunition would be at once known, by simply recording the elevation at which the standard distance was reached, and the length of the shell, expressed in diameters of the bore. The longer the projectile, and the lower the elevation at which it is propelled, the greater is shown to be the power of the gun.

One thousand yards may be now considered a short range for artillery; and as upwards of 11,000 yards (more than six miles) has been attained, a standard range of from 2 to 3 miles would answer the purpose. If this were carried out, any one would be able to form a correct opinion of the value of any particular gun. For want of some standard, very confused notions now prevail on the subject of rifled guns.

It is very difficult to attempt to compare two guns having nothing in common. For instance, to compare the 7-inch service breech-loading gun and the 7-inch Whitworth:—

	Elevation.	Shell. Diameters long.
7-inch service-gun, range 3,660 yards.........	9° 54′	2
7-inch Whitworth, range 5,000 yards.........	10°	$3\frac{1}{2}$

Although it is obvious how much more powerful one gun is than the other it would have been far better for the ranges to have been the same, and the difference shown only in the elevations, and the length of the projectiles given in diameters of the bore. The length of the Whitworth shooting gallery at Manchester being 500 yards, it was the practice to compare the performances of different rifles and their amunition at that distance, and 500 yards became the standard of length.

The following shows the qualities of the Enfield and Whitworth, as developed in April, 1857:—

	Elevation.	Length of Bullet. Diameters.
500 yards range Enfield rifle, large bore.........	1°	2
500 yards range, Whitworth rifle, small bore...	1°	3

Other qualities, such as accuracy or figure of merit, charge of powder, weight of bullet, weight of rifle, &c., it may be desirable to know; but the key-notes are elevation and length of shell, which at once decide the value of the arm. In 1852, the average shooting of six rifles made by the best makers in London was 33 inches deviation. The shooting of each rifle is recorded in a book printed by the War Department, which I have seen, and which affords evidence of the great advance made in the science of gunnery since that time. The shooting of the Whitworth rifle is now, as it was at Hythe in April, 1857, $4\frac{1}{2}$ inches at 500 yards with ten successive shots.

An infantry soldier will probably be as well armed with the new small-bore breech-loader, as far as accuracy, rapidity, and distant firing are concerned, as he is ever likely to be. He is now able to fire 8 projectiles, 1 oz. each per minute, and make good practice at one thousand yards. But the power of infantry for attack or defence, even with the new breech-loader, falls far short of what small bodies of infantry could do, if armed with 3-pr. field-guns drawn by two horses; each man would be able to fire a far greater average weight of ammunition, and of much more destructive character that with the rifle. The trajectory at 1,000 yards for the 3-pr. gun is not one-half that required for the rifle.

Blackfriars Bridge and Holborn Viaduct.

The new Blackfriars Bridge and the Holborn Viaduct were, two months ago, opened for public traffic by her Most Gracious Majesty the Queen, with great state and formality. As you are all aware, our Vice-President, Mr. Cubitt, designed and constructed the bridge; and our honourable member, Mr. Haywood, as Engineer of the City of London, the viaduct. I mention these two great works to record the date of the simultaneous completion; at the same time I shall place a mark against the name of each engineer, as a reminder of what they owe and are bound to pay us—descriptive accounts of their respective operations—which are monuments of grace and utility, admitted by all, and needing no eulogium from me.

Madrid Waterworks.

Although that fine country, Spain, has long been in a state of chronic disorder, and for the last sixteen months in the agonies of an interregnum, more than one great work, besides the railways, has been accomplished within the last few years, the principal one being the grand reservoir and aqueduct for the supply of Madrid with good water. The total cost was £2,300,000 sterling, including additional work on the principal weir, founded on limestone rock, through which great leakage took place.

Atlantic Railway.

In the course of last summer our Transatlantic brethren completed the extension of their railways between the Atlantic and Pacific oceans, across the Rocky Mountains. The accounts hitherto received have been perhaps too highly coloured by local enthusiasm; but I have been supplied with statements sufficiently authentic to prove, that on the day previous to the formal opening, ten miles of permanent way were actually laid by one working party, and about eight miles by another and rival party, each striving to attain the given point of junction. However, since these and similar exertions at other parts, to force the locomotive engines, in some way or other, over the lines, an official inspection has ascertained that over the whole length of the newly-opened railway, it will require a further expenditure of some two millions sterling to perfect the way, and to comply with the conditions of the contracts. The requirements have not been thought unreasonable, and the money is forthcoming; meanwhile the traffic throughout is continued without interruption.

Wire Tramways.

A few words only on a cheap and novel method of transport, useful for short distances in mineral and rough districts where railways cannot be made economically. The system is by Mr. Charles Hodgson, and may be briefly described as a continuous development of the plan often adopted in India, Australia, and America, of bridging over rivers by means of a wire rope on which loads are transmitted in a bucket suspended by a pulley.

The endless wire rope, now adopted, is supported on a series of pulleys, carried by substantial posts, about 70 yards apart, on the average, passing round a clip-drum at the end, and worked by an ordinary moveable steam engine. Boxes, carrying from one to five cwt., are hung on the rope, in such a manner as to maintain the load in equilibrium and pass over the supporting pulleys with ease. The line is worked at a speed of about 5 or 6 miles an hour, and, the rope being endless, the full boxes travel on one side of the supports, the empties return on the other.

However rugged the country, the line can be constructed quickly, and without necessitating much more engineering work than for an ordinary line of telegraph. The cost of a line calculated to transport 100 tons a-day appears to be about £400 per mile, complete for working, and the average cost of transoort is about twopence per ton per mile, including maintenance. The plan has been in operation about 10 months. About 35 miles of line have been made, and upwards of 100 miles are in construction, all in different places.

Mont Cenis Tunnel.

The long tunnel popularly known as that of Mont-Cenis, really passes below a different mountain. It connects the railways of Italy, converging at the town of Susa, at the foot of the eastern slope of the Alps, with the railways of France, at present terminating at the village of St. Michel, in Savoy, west of the range. The mode of driving this tunnel has been before described; at present, I have simply to note its progress. The total length of actual tunnel is 12,220 metres, say 7⅝ English miles; the aggregate length of the driftways, completed from each end, is 10,598 metres, or 6⅝ miles; so that there is only one mile of driftway to finish; the rate of progress being from 3½ to 4 yards per day, the entire piercings from end to end may be expected early in the spring of 1871. The enlargement to full size, and the lining of the tunnel, are always kept up to about 300 yards behind the headings in each direction. Assuming that the tunnel, with the deep-cutting approaches at each end, will be finished in the course of the year 1871, it will have occupied thirteen years in construction, at a cost not less than four millions sterling.

Mont Cenis Railway.

The Mont-Cenis railway is a work quite independent of the lines which the tunnel is intended to connect. It cannot possibly be called a rival scheme, though this railway contrasts most remarkably with the tunnel, and affords a complete solution of the difficulty of surmounting mountain ranges at a moderate cost; the practical results of the working of this line, which after all is merely an experimental and provisional one, must be considered by all who view it without prejudice, highly satisfactory.

Only three interruptions have occurred since it was opened, and none of them were from any cause arising from the system itself. The first in August, 1868, was occasioned by heavy floods, which ravaged the whole face of the country, and greatly damaged the chaussée, on which the railway is laid; in this instance the passage across the mountain was stopped for three days only, but was equally blocked for diligences and road waggons; there was a further partial hindrance during ten days subsequently, when passengers and goods were transported in sledges for distances varying from two to ten miles. The second was in 1869, arising from snow storms and hurricane drifts. The third, in December last, was from similar causes, but the transit over Mont-Cenis was never totally closed, though it had for some days to be made partially by sledges, and, of course, considerable irregularity unavoidably resulted.

The concession for the Mont-Cenis railway expires with the opening of the Mont-Cenis tunnel and approaches, previously described. I presume most of my audience are aware that the rails are laid on the outer edge of the highway across that part of the Alps, on a narrow gauge, having extremely sharp curves, and excessively steep gradients—the curves and gradients, in fact, of a mountain road—inasmuch as the rails follow its surface. The locomotive engines obtain the necessary adhesion, and at the same time ensure perfect safety to the train, by the lateral pressure of horizontal wheels upon a central rail.

Owing to the limited date for its existence, which will probably be only two or three years longer from this time, it has been quite out of the question to construct all the necessary protective works, which would have been executed for a more permanent line: then it passes over one of the Alpine summits, in a region exposed to the most violent winds (Tormentos) and drifting snow. From peculiar causes, at first perhaps unavoidable, the mechanism of the moving power was, until very lately, imperfect in design and inferior in workmanship, the result being continued repairs, with scant power, and consequently only half loads; the fact being that the old stock could hardly drag 20 tons behind it, whereas the new engines will take up 50 tons, exclusive of their own weight.

The Mont-Cenis railway, between St. Michel and Susa, is 50 miles in length, and has cost exclusive of royalty and interest during construction, about £7,070 per mile; engines and rolling stock £862 per mile. Total, £7,932, say £8,000 per mile. Had the line been constructed on the usual gauge, and with a more solid permanent way, the cost would have been £3,000 additional, altogether £11,000 per mile. As a maximum expense obtaining all the unfettered advantages of the system, £12,000 including stations, may be safely reckoned upon as the cost per mile of similar lines in future through a mountainous country. With gradients and curves, such as would be warranted and adopted by lines hereafter laid down on this central rail system, a comparison of distances over such a country along lines prepared for ordinary locomotive engines, to travel over gradients of 1 in 30, probably the steepest allowable without lateral adhesion, the time of moving, and first cost would probably be as 1 to 3; this difference of distance must also be taken into account when calculating and comparing the cost per mile of working over each system.

As regards the expense of working, the present actual cost on the Mont-Cenis railway can hardly be taken as a fair criterion. Owing to the exceptional circumstances of its construction, the narrowness of gauge and the inferiority of the first engines, the working expenses have been peculiarly heavy—viz., fuel 1s. 6d., engine repairs 1s. 8d., wages 6d. (in all for locomotive power 3s. 8d.,) general charges 4d., permanent way 1s., making a total of 5s. per train mile. The general charges, repairs and maintenance thus calculated, would of course be reduced by a higher mileage, as the rapairs are very onerous, but the new locomotives will reduce the expense of moving power one-third. The yearly train mileage is about 113,000, or 310 miles daily. The engines are perfectly steady on the ascent and descent; in either direction, it seems next to impossible for engines or trains to get off the rails; up to the end of 1869 about 68,000 passengers have travelled over this line without loss of life or limb.

Suez Canal.

This renowned work is about 160 kilometres, nearly 100 English miles, in length, from Port Said to Suez. About 63 miles are along ground which is at, or nearly at, the ordinary water level of the canal; 37 miles are over ground above that line. The mean level of the Red Sea is only 6 inches higher than that of the Mediterranean; the tides of the Red Sea are but small; those of the Mediterranean very feeble, consequently there are no locks. Our worthy member, Mr. J. F. Bateman, F.R.S., in his recent letter to the President of that learned body, has given its history and anticipated most of what I might have said about the Suez Canal; but I have received, though too late to introduce here, some new and interesting particulars, which I will endeavour to put before the members in some accessible shape at the earliest opportunity.

Meantime I mention one special fact. Between the 15th May and 15th June of last year, when the works were in full swing, 58 immense steam dredgers and 11,000 labourers were at work, and upwards of 2½ millions cubic yards of materials were got out, being at the rate of more than 80,000 cubic yards daily. On the question of maintaining the slopes and depth of water in the canal and in the two harbours, there seems no doubt, though at a certain heavy, but probably yearly-decreasing expense. Additions, improvements, and precautions have still to be taken, but in the course of the coming spring I believe a depth of 26 feet of water throughout will have been attained. The expense up to the last accounts appears to have been about sixteen millions sterling, and, when properly finished, the total outlay of every kind, including a vast per centage for interests and discounts, may, by possibility, be swelled to twenty millions. Many good judges affirm that it will be a very excellent financial speculation at this large cost. I, myself, believe it will be, although I am bound to confess that at one time I thought otherwise. It is due to Mr. Daniel Lange, the representative in this country of the Suez Canal Company, and their strenuous unflinching advocate, to record his persistent opinion of its ultimate success.

But my proper business is to consider it as a work of engineering, and as such it is a great, important, and successful undertaking, and to echo my friend Bateman's words, "great as respects its magnitude and the country in which it has been executed. . . . A great work more from its relation, however, to the national and commercial interests of the world than from its engineering features. In this light it is impossible to over estimate its importance. It will effect a total revolution in the mode of conducting the great traffic between the east and the west, the beneficial effects of which it is difficult to realize. It is in this sense that the undertaking must be regarded as a great one, and its accomplishment is due mainly to the rare courage and indomitable perseverance of M. Ferdinand de Lesseps, who well deserves the respect he has compelled, and the praises which have been bestowed. . . . By cutting across the sandy ligament which has hitherto united Asia and Africa, a water communication has been opened, which will never again be closed so long as mercantile prosperity lasts or civilization exists."

In entering upon my engineering reminiscences, I find they extend far back, and I am tempted to begin, as the legends of the nursery do, with "Once upon a time!" Well, then, once upon a time, there was no gas in

London! Moreover, no steamers on the Thames! Can the younger part of my audience realise in their minds these facts? Yet so it was only sixty years since. Why do I mention gas? It is to show that great as are the blessings which science and philosophy have conferred on the world, their professors in this, as in many other instances, hesitated to sanction practical men in carrying out to their logical conclusion the principles they had taught them. The examination of the properties of coal gas long remained a philosophical experiment merely. Chemists worked laboriously with the principal materials of a grand invention, without making anything out of them for thirty years, until Murdoch lighted his own house in Cornwall with gas in 1792.

The subsequent success of Murdoch, and afterwards of the elder Clegg, in gas for the manufacturing districts, did not meet that attention it ought to have done, and while Murdoch was struggling with ignorance, prejudice, and interested opposition, Le Bon, an ingenious Frenchman, made a bold but happily unsuccessful attempt to rob him of his honours by proposing, about 1801, to introduce into Paris gas distilled from wood. Nevertheless, it was not till 1813 that the first public thoroughfare in this this metropolis was lighted with gas. It is interesting to us to know that a part of this thoroughfare was Great George Street, Westminster. Previously our deceased member, the elder Clegg (I am condensing from the work by his talented son, also a member of our Institution, prematurely lost to us), the elder Clegg, I say, confident in its practicability, proposed to light all London with gas; and then occurred his memorable passage—not of arms, but of wit, with Mr. (afterwards Sir Humphry) Davy—"Impossible, Mr. Clegg," said the great chemist, "you would want a gasometer as large as the dome of St. Paul's." "Why not?" was the retort of the shrewd practical engineer. Nevertheless, it was many years before the prejudice against large gasometers was worn out, and even now I am not quite sure that is so. Most extraordinary precautions were at first adopted, under compulsion, to protect the public from imaginary danger.

Steamboats had not, perhaps, so much prejudice to encounter as was the case with gas; but a considerable period elapsed, after their success had been established on the Clyde, before they became naturalized, as it were, on the Thames, and obtained regular traffic. Long antecedently the bathing towns of the Isle of Thanet had been favourite resorts for the Londoners, as Gravesend, and other places on the Thames, had been for ages. But how about getting down the river on easy terms before steam came for those who could not afford the luxury of posting, or the less costly but heavy stage coach? My young friends must imagine, for the lower class of passengers between Blackwall and Gravesend, a covered boat going only with the tide, known as the Tilt Boat, and much resembling the small craft common on the Thames in the time of Henry VIII. But for longer distances there were the once famous Margate-hoys—smart sloops like our modern yachts. With a strong favourable breeze, and by a careful study of the tides, the skippers of these hoys might get down to Margate in the course of a summer day. But with contrary winds, and in stormy weather, woe! to the unhappy holiday seeker whose time was limited, and who had not laid in a due stock of provisions. Fortunate if he fared no worse than was once my hard fate—to pass more than three days and nights in a crowded hoy between London and Ramsgate. Luckily no gales, but slight baffling airs and calms—anchored half the time to avoid the back drift of adverse tides, and wearing out the lingering day by attempting to catch mackerel with a red rag to supplement our provender, short in our allowance of bad water, and having the fear of the press-gang constantly before our eyes.

Passing over intermediate years, let me come to my proper task, and attempt so recall some of the memorable chain of occurrences in the earlier days of the railway system, when that grandest improvement among the many ameliorations of the first quarter of the nineteenth century began its earliest struggles for general adoption. It is to the courage and enterprise of the mercantile and manufacturing communities of Liverpool and Manchester that we owe their introduction and benefits such as we have enjoyed during the last forty years.

The trade to and from the port of Liverpool had long been outgrowing the existing means of inland carriage. The two great carrying companies, popularly known as the "Duke" and the "Old Quay," had provided it with water transport during three-quarters of a century, as, for a shorter period, had the "Leeds and Liverpool Canal;" and the many waggoners along the rough paved highways had supplied the road conveyance. But it may readily be imagined that, with the rapid increase of commerce subsequent to the close (in 1815) of our long series of wars, all of them were insufficient.

When the first steam engine had only been erected in Manchester in the year 1790, not a power loom introduced until twenty years later, and the population scarcely 40,000; when the port tonnage and population of Liverpool were small—when the first casual importation of eight bales of American cotton in the year 1784 was so strange, that it was seized by the Customs officers, under the conviction that it could not have been the produce of the country which the invoice stated it to be—the trade of both towns was unimportant compared with that of 1824—by which time Manchester had 150,000 inhabitants, 200 steam engines at work, and 30,000 power looms employed; then dock dues at Liverpool were paid by 10,000 vessels, the population was 135,000, and upwards of 400,000 tons of cotton were imported yearly; goods in transit between Liverpool and Manchester equalled fully 1,200 tons daily, besides upwards of a million tons of coal arrived annually into those two towns. Thus the aspect of commercial affairs had totally changed, though the means of conveyance remained unaugmented and unimproved; hence arose vast pressure and enormous sacrifices to ensure speed and certainty in the delivery of goods. This could only be done by land carriage, sometimes at almost ruinous cost. Some remedy was imperative, some competition indispensable, and the inquiry became necessarily limited to the form in which it should be devised and applied; it was not long before deciding that the remedy should be by means of a railway.

Railways, though rude, had existed in the coal counties on the Tyne and the Wear for 200 years previously, but since the beginning of the present century they had improved and multiplied rapidly, but were still only short isolated private undertakings, appropriated exclusively to the transit of coal. In 1822 the first public railway for goods, coals, and passengers was proposed between Stockton and Darlington; it was unsuccessful in Parliament from the opposition of the landowners and coal proprietors, but next year the act was obtained. About this time, William James, a London engineer, had suggested just such another railway to the mercantile men of Liverpool, to supply the great want of conveyance between Liverpool and Manchester, and James made the first actual survey. It was not adopted, but the idea was entertained and ripened. The water-carrying companies refused to reduce their tolls, the alternative of road conveyance was impracticable, from its limited resources and great expense; but independent of tolls, the endless delays on the canals, the pilferage of the merchandise in transit, and the terminal obstructions from want of space, left no hope of improvement; and in 1824 the first prospectus for the Liverpool and Manchester Railway was issued, the appointed committee prepared their plans under the advance and direction of George Stephenson, and lodged them for application to Parliament in the ensuing session.

The anticipated strenuous opposition to the scheme was not long in becoming realised. The three bodies of canal proprietors, each in itself no despicable opponent, forgetting their mutual animosities and former disagreements, banded against the new rival in formidable array, acting on common impulse, organised under most skilful direction, upholding with tenacity their vested interests, claimed as rights; and prepared at all hazards to resist and crush down so intolerable an innovation on established modes of communication, and on their chartered privileges and long-maintained monopolies.

Two noble peers, Lord Sefton and the great grandfather of the present Earl of Derby (whose estates the railway crossed, and have since so vastly improved those belonging to the latter nobleman), made common cause with the canals to prevent the passing of the railway bill. It was battled during three months through the House of Commons. Every possible objection was taken. Imperfect plans, erroneous levels, interference with parks a mile distant, danger, nuisance, and incompetence of locomotive engines, deficiency of estimate, impracticability, especially in crossing Chat Moss. One very eminent engineer affirmed that the probable expence of crossing that moss would exceed £200,000, though the real cost was actually within £30,000.

I should inform those of my readers who have not watched the different changes which have taken place in the practice of passing private bills through Parliament, that in those days committees on bills, and even on standing orders, were open to every member of Parliament who chose to attend, were it solely for the purpose of voting upon the preamble or merely on a particular clause. The whip for the first division was tremendous. The preamble of the bill was carried by a majority of one only in the open committee to which 73 members had been pressed. It must then have been considered hopeless to persevere; next day the clause empowering the company to make the railway was lost by a vote of 19 to 13; the clause to take land was also negatived; the promoters then withdrew the bill, and thus ended the first act of the great railway drama, which, even at the present day, is still far from being played out, although 100,000 miles of railway are now laid on the face of the globe.

Nothing daunted, the high-spirited committee, the very *élite* of Liverpool, called their parliamentary supporters together on the third day after the loss of their bill, and, encouraged by them, resolved to persevere. And, hear it my fellow-countrymen of Ireland! the most cogent argument used by the leading political men of the day who attended the meeting—an argument repeated in the new prospectus of the railway—was, the benefit which the railway would produce, directly and indirectly, to the agricultural interests of Ireland,—a benefit I can testify from my personal knowledge ever since, has been most abundantly realised; and, considering that it was an argument brought forward five-and-forty years ago, there is good ground for maintaining that the best interests of Ireland were then, as now, quite as much cared for as those of Lancashire.

It happened that I had returned, some two years previously, from occupations on the continent and in North America, both civil and military, all connected with engineering, occupying repeated absences from this country. Having watched the few railways then made, or making, I was fortunate in being selected by Messrs. Rennie to take charge of the new surveys, which the Liverpool committee immediately ordered under the direction of those eminent engineers. But the opposition of canal owners and land proprietors had become redoubled—and it was in the course of carrying out this duty that I was brought into contact with the celebrated Mr. Bradshaw, the devoted trustee under the remarkable will of that Duke of Bridgwater who employed Brindley to make his canals, and had charged Mr. Bradshaw with the sole and absolute control of them, and of his large estates, for the benefit of his future heirs, which he exercised for nearly half a century.

I was brought up before Mr. Bradshaw, at Worsley Hall, on a pretended charge of night poaching and trespassing—for I was often obliged to make surveys and take levels by moonlight and torchligbt, so strict was the watch kept by day, by order of many landowners to prevent engineers from completing the necessary plans and sections. Mr. Bradshaw had contrived to earn himself a terrible name for severity, but I found him a gentleman. My only reason for recurring to such a mere personal adventure is, that some not unfriendly discourse passed between us on that occasion, which I communicated to the Liverpool committee. This led, I have good reasons for believing, to communications which, before the end of 1825, ended in those arrangements by which the then Marquis of Stafford, for himself and those of his family who were ultimately to benefit in the profits of the Duke of Bridgwater's canal, took one thousand shares in the Liverpool and Manchester railway company, with the privilege of nominating three of the directors, arrangements confirmed by the company's first Act of Parliament.

On the 25th September, 1825 (I note the special date) the Stockton and Darlington railway was opened for public traffic. The surveys of the new railway between Liverpool and Manchester, commenced in the July preceding, were completed and lodged in November; then public attention awakened to such projects, and early in 1826 the bill was again introduced into Parliament, under less discouragement. The opposition, however, though not so compact, was as keen as ever, and the passing of so important a measure required every effort, every precaution, on the part of the promoters. The leading counsel opposing was the late Baron Alderson, the most accomplished mathematician and man of science then at the bar, prompted in his crucial examination of engineers, by your esteemed Past President, George Bidder, then as well known for his marvellous power of mental calculation, as he has since been as a scientific and practical engineer. Few of my audience will be disposed to infer, judging from his subsequent career, that my old opponent Bidder was the most formidable enemy of the railway in its first parliamentary warfare.

In spite of him, however, the preamble passed the ordeal of committee, this time with a majority of 43 to 18. The third reading was opposed in the Commons by the illustrious Lord Derby (lately deceased), then the Honourable Edward Geoffrey Stanley, who made his almost maiden speech in that House against the bill, with all the ardour of his character; but on a division, the numbers were 88 in favour, 41 against. The struggle was renewed in the Lords' Committee. One of the counsel for the railway was William Page Wood, then a junior barrister, now Baron Hatherley, Lord High Chancellor, and a very near neighbour of ours. On their last day of meeting in Committee, thirty-two Peers were present, when the very old Earl and his son-in-law, Lord Wilton, were the only dissentients. The third reading was carried without a division, though not without hostile speeches; the royal assent soon followed, and on the 26th May, 1826, a general meeting of the subscribers was held in Liverpool, and the newly-appointed directors held their first sitting on the following day. Soon after George Stephenson returned to the post of engineer-in-chief, and the railway works commenced and were vigorously pushed on for three years, until approaching near to completion, when it became necessary to settle the question of the motive power to be used on the railway.

It would occupy the time usually assigned to more than one address were I to pursue the interesting record of the steps taken to solve this question; but I am not attempting an historical analysis—merely selecting a few reminiscences. I should have been very glad to have noted the proceedings known as the "Rainhill Experiments," having been myself present the whole time, in October, 1829, when the competitive trial of locomotive engines took place, ending in the grand prize being awarded by impartial judges to George Stephenson and Henry Booth jointly. It is from Mr. Booth's publication that I have been most unscrupulously abstracting. I will refer those who may be disposed to enter into details of such remote date to the pages of the Liverpool newspapers and the "London Mechanics' Magazine" of that period. Trustworthy, impartial accounts are to be found therein, and full justice done to my old friends, Braithwaite and Ericsson, whose engine the "Novelty" was long remembered as the beau idéal of a locomotive, and which, if it did not command success, deserved it.

A great gathering of engineers from all parts was, of course, in Liverpool; and, as Englishmen are said not to get on well on important business without dinner demonstrations, the engineers gave on this occasion a grand banquet to the directors and of the railway, and to the competing locomotive engine builders. Of course speeches were made and healths drunk, and we toasted each other and everybody, except the waiters. Will you excuse me if I read from a newspaper report of our feast (in the *Liverpool Albion*, of the 12th of Octoder, 1829), two short predictions of mine about railways. I had had the honour assigned to me of returning thanks for the toast of the "President and Institution of Civil Engineers," and what I said is thus reported:—"Mr. Vignoles, as a member of the institution, returned thanks for Mr. Telford, to whom as the consuctor of many of our most important public works, the toast was due. His (Mr. Vignoles's) first step in life was as a military rather than a civil engineer; and as he was deputed to propose a military toast, perhaps he might preface it by some anticipation of what steam would do, in a military point of view. Supposing such a general as Napoleon were to effect a landing on our coast with a large and powerful army, and that he even were to be victorious upon his landing; armed as this country is shortly to be with railroads and locomotive engines, brief would be his triumph; for by return of post, as it were, parks of artillery and the whole military force of the country could be poured upon him, without even the fatigue of a march. Mr. Vignoles concluded with giving "The Master-General of the Ordnance and Corps of Royal Engineers."

And a little later in the evening, having had to propose the health of the three judges of the Locomotive Competition, I stated, as reported:—"Being engaged in laying out a railway between Goole and Barnsley, he (Mr. Vignoles) hoped to see that accomplished and made part of the union between the two sides of the kingdom, and that it might put it into the power of that part of the country to supply the metropolis with the article coal, at present furnished through sea transport by the Great Northern proprietors, whose monopoly he trusted would then soon be put down."

As regards my latter prophecy, my friends, taking them either in alphabetical or geographical order, Barlow, Cubitt, and Harrison have now pretty well realised what I uttered about bringing coal into London by railway, though they only began some twenty-five or thirty years after it was first thought about. Still it has been most effectually accomplished. In respect, however, of what railways would be able to do, in case of the momentary success of an enemy invading this country, I have to remark that one of the earliest duties required by the War Office, after the establishment of our Engineer and Railway Volunteer Staff Corps, was to point out the means by which, in the event of such a disastrous occurrence, the railways could practically protect us; and the answer we returned went to the effect of demonstrating, that within forty-eight hours after the alarm had been sounded, the whole military force of the country could be poured down upon the enemy, on whatever coast the invading forces might land, without, excepting in a few limited cases, the fatigue of a single day's march. I would have asked our illustrious honorary member, Sir John Burgoyne, whom I hope I may be permitted to call old friend (whose illness, I regret to say, has alone prevented him from doing us the honour of being present this evening), but in his absence I shall appeal to the Quartermaster-General Sir William Gordon, whom I am proud to see here, whether our replies were not complete and satisfactory, and whether what was thought at the time to be the mere boast of a dreaming enthusiast, is not now ready for realisation at any hour—though, God forbid, that that hour should come! even though it found us as fully prepared, as forty years ago I ventured to anticipate we should be.

I am thus led to a subject which I had intended to have mentioned subsequently, but here seems to be the most appropriate place. The civil engineers, as a body, were first so called by Belidor, to distinguish them from the military engineers. It may be readily understood, however, in how many cases the military professional operations would partake of the civil elements. On such occasions when appealed to, as in several recent instances, we have always been most willing to give our military brethren any advice and assistance in our power, as has been repeatedly acknowledged.

But now a new era is coming upon us, which will bring us much more in connection with the military service. First, by the organisation of our national Volunteers, in which we, as engineers and artizans, have largely partaken, giving to the movement our professional skill; and secondly, in consequence of the general extension of railways, and the recent introduction of the new powerful arms and implements, none of which have been as yet subjected to any regular fully-devised system, even in the most recent wars, but which will necessitate increased influence of engineering in military operations, the full consideration of which we, as civil engineers, including the most eminent of our body, are using our best efforts to develope; and we have the satisfaction of finding these efforts appreciated by military and naval officers of the highest distinction and experience.

I need scarcely say that a year or two before, and of course immediately after the opening of the Liverpool and Manchester railway, the attention of the public generally had been drawn to the new system of locomotion; a number of projects were brought forward, and many were in contemplation, especially a railway from London to Birmingham, and another from Birmingham to Liverpool, for amalgamation had not then become the order the day. Among others was a plan for connecting London and Paris by railroad, *viâ* Brighton (or rather Shoreham) and Dieppe, the long sea transit not being then deemed so objectionable, considering the distance between the two capitals by this route was the shortest by sixty miles.

A powerful combination of capitalists was formed, and soon after the change of monarchy which placed Louis Philippe on the throne of France, I was sent over to negotiate for a concession in the French dominions. I had the honour of several interviews with his Majesty; the celebrated statesman, *Thiers*, then Minister of Public Works, was sent to England, and soon after Monsr. Le Grand, his Under Secretary of State, came over. I had the honour of escorting them, one after the other, through our manufacturing districts and along the railways, some of which I was constructing, and I thought I had convinced them both of the advantage which the railway system would be to France.

After some considerable time occupied in inspecting everything which I thought most likely to interest these two chiefs of the public works of France, and conveying them over road and railway at a pace at which I am sure neither of them had ever moved before, M. Thiers took leave of me in a speech full of compliments and polite phrases, which I will attempt to paraphrase in plain English :—"Mr. Vignoles," said the accomplished statesman, but bad discriminator, "I am infinitely obliged to you, and I think you a very clever fellow, but, do you know, I did not believe a word of what you told me before I came, and now I cannot see the great advantages you were constantly dwelling upon. You have good canals—but very small, and ours in France are much superior. As for your roads, they are very good, but I have not met a merchandise waggon on them in the whole of my journeys. I do not think railways are suited to France!—and as to your vaunted posting, we go quite as quick in France." Perhaps this last remark was not to be wondered at—for M. Thiers had insisted on bringing over to England his own heavy lumbering vehicle, quite *à la* Louis XIV., with immense lamps like the old Paris reverberators, at the four corners on the top of the coach, which carried heavy Imperials, and eight or nine persons in and out, requiring six horses most of the way.

M. Thiers returned to Louis Phillipe, and reported against the introduction of railways. He made violent speeches in his place in Parliament as Minister of Public Works adverse to them, and the benefit of railways to France was postponed for eight or ten years, of which M. Thiers has been repeatedly and sharply reminded by his political opponents when lamenting his short-sightedness. But his deputy, M. le Grand, was somewhat more reasonable. He left a staff of young engineers to study our system of road-making, and it was copied closely in all the new roads subsequently made, and the Macadam principle of repairing was adopted; and, in fact, from that period the roads throughout France have been changed, greatly for the better. I cannot but acknowledge that the way in which roads in that country are now kept is superior to our own—especially as regards our mode of forcing good horses and light carriages to grind down broken stone. In France they keep many of the roads clear from mud in winter, and from dust in summer; and where road materials are scarce and dear, they find a great economy in doing so.

Mere politicians called upon to consider and judge of engineering naturally fall into errors which, if excused, cannot be easily forgotten; but what can we think, or rather what ought the engineers of France to think, of a system which placed at their head a statesman who virtually robbed them of the glorious opportunity of doing for themselves and their country what, after years of injurious delay, fell into the hands of English engineers and capitalists, they becoming the first practical introducers, on a large scale, of railways into France. A system which, in my judgment, notwithstanding many advantages, hangs like a dead weight on the talent, genius, and invention of that country.

However, scientific men in this country, as elsewhere, sometimes commit queer and sad mistakes. Witness those by that very learned man, Lardner. At the Mechanical Section of the British Association meeting in Dublin, in 1835, he harangued a brilliant audience on the extreme danger of travelling at high speed, arising from the effects of centrifugal force, over a railway curve of less than half a mile radius, at the very hour when a large portion of those present had come to hear him, and were going home again, over just such a railway curve, and had been travelling over it rapidly for months previously; or the much more discouraging assertion, by the same learned professor (only hazarded, perhaps, at the same meeting, or about the same time, and not so capable of immediate refutation, namely), that it was a mechanical impossibility for steamers to make successful voyages across the Atlantic ocean.

One more and the last reference to antecedent times. When the practice of railway making and working was firmly established in Great Britain, and the rush into Parliament for new lines was beginning to attract the notice of our legislators and the executive, the Government were desirous of laying down, before it became too late, a good system of railways for Ireland, and appointed for that purpose the "Irish Railway Commissioners," to make due inquiry and investigation, and to report thereon. It was impossible then, as it would be now, to select any body of men more perfectly qualified to discharge this duty—Drummond, the the Under Secretary for Ireland, who stood high in science; Burgoyne, the Chief Commissioner of the Board of Public Works; Griffith, in charge of the Valuation Department of the Ordnance Survey; and Barlow, Professor of Mathematics of the Royal Military Academy, Woolwich, the father of the two distinguished brothers, our fellow members. The Secretary was the late Harry Jones, an officer with practical knowledge, both as a civil and military engineer, afterwards Governor of the Royal Military College at Sandhurst; and the statistical duties were assigned to Harness, a gentleman peculiarly well qualified for the office, lately at the head of the school of practical military engineering at Chatham. To the commission were attached two civil engineers in the full exercise of their profession.

A report from the Commissioners followed in due time, in which it was clearly proven that only a few principal lines of railway could, looking forward to all probable increase of traffic, pay yearly interest on capital expended, and then not more than 4½ per cent. on the average of all the lines. The report demonstrated that minor and branch lines would be unprofitable and probably ruinous; and it concluded by recommending that attention should be devoted to the main railways alone, which it was indicated ought to have a uniform gauge of six feet two inches. This report was received with distrust, and treated almost contemptuously; the idea of government dictating to capitalists how to invest their money was scorned; and the railway mania extending to Ireland, lines were designed with different gauges, and executed through districts where, to the dispassionate observer, profitable returns appeared to be hopeless. The consequence has been as foretold; very few of the lines pay, and for those which do, the interest is, with one or two exceptions, under 5 per cent., and all the railway companies are now clamouring at the doors of the imperial treasury to be bought up, under the pretence of relieving the Irish people. And this from the representives of the very speculators who had persisted in constructing such unremunerative lines, in spite of the proofs and recommendations of the Railway Commissioners for Ireland, whose judgment should have been relied upon and advice followed in the first instance, and the accuracy of which has since been so abundantly proved.

It has been often urged by theoretical writers, that our Government should have interfered to check the extension in Great Britain of rival schemes, and unprofitable lines of railway. Looking, however, to what occurred in Ireland, it appears altogether unlikely that railway men would have paid the slightest attention to any check attempted, short of a prohibitory Act of Parliament, which it was and is utterly hopeless to expect could pass. The railways have run their course, and their proprietors now reap the the bitter fruits of by-gone contests.

But under a strong government, and with the system and control I have described, the French have had the financial interests of railway shareholders tolerably well guarded, by measures I cannot pause to describe. The broad practical results in the two countries stand thus contrasted: In the United Kingdom, the general public have obtained the greatest benefits, and, speaking broadly, the railway proprietors have paid for them. In France, shareholders have been spared the competition of rival lines, and the construction of useless branches, and fair interest on their capital has been secured to them; but, on the other hand, the general public have neither the freedom, facility, nor advantage of railways, particularly in passenger traffic, such as we enjoy.

Before finishing, I will address a few words to the student-class, which has been established recently, with a view of affording opportunities to the rising generation of engineers for improving their theoretical eduction; but hitherto, if I may judge from the comparative paucity of their attendances, particularly in the library, they have not availed themselves to the extent they might have done of what has been offered them. We, as an institution, do not profess to educate, and it depends greatly, I had almost said exclusively upon the student, to educate himself. Nevertheless, it is indispensable that he should go through a regular course of study, and we have collected from every part of Europe, detailed accounts of the system of education for engineers pursued in different countries. Our distinguished member, Dr. Pole, F.R.S., is preparing an analysis of these, which we hope will be in circulation in the course of the present session.

Meantime, let me recall to you the aphorism of the late Mr. Hosking, that it is "the combination of the workman and the man of science that forms the engineer." Dr. Pole informs me that the papers which have been collected, all point to the French system, as pursued at the Ecole des Ponts et Chaussees, being most perfect theoretically. I have already pointed out to you how much more completely our brethren on the oth r side of the channel are educated, and I would stimulate you to make greater efforts in this direction for your own good. Dr. Pole has confirmed me in what I had myself surmised, that it is the opinion of French engineers that we excel them in practical skill, but that they excel us in theoretical knowledge. Let me implore you, therefore, to reflect that if our scientific education were more nearly equal to theirs, our superiority would be beyond question.

In going into the world and beginning the struggle of professional life, keep in mind that what is true in politics, religion, law, and all other pursuits is equally true in engineering—earnestness—to do what you have to do with zeal and assiduity, so that having yourselves thoroughly imbibed sound convictions, you may be able to carry with you those disposed to confide in you.

The first Napoleon said that "Engineers ought to have magnificent ideas;" and it is no doubt well always to have an ideal perfection in view: but do not suffer yourselves to be carried away in pursuit of an *ignis fatuus*. It is not given to every one to project such a work as the Suez Canal, the Mont Cenis Tunnel, or similar grand undertakings. Conceptions, such as these, generally emanate from statesmen, and far-judging thinkers in their cabinets, who call upon the engineer to aid them in carrying out their ideas. Do you rather aspire to works of every-day utility, and guard yourselves especially from supposing that the merit of an engineer is measured by the expenditure on his works. In this country, at least, the time has gone by when it was supposed that the public would ask, not what a work costs, but who the engineer was that did it. I have always inculcated the doctrine that the success of an engineer is best ensured by the pecuniary benefits accruing from his works, as commercial speculations.

In reference to the contrast between theoretical and practical work, the late celebrated Dr. Whewell, Master of Trinity College, Cambridge, said in a lecture:—"Looking at the progress of art and science in past times we find that, in general, art has preceded science. Men executed great works before they had a scientific insight into the principles on which the success of their labours were founded. There were good artificers in metal before the principles of chemistry were known. Mighty masses were raised into the air before there was a theory of the mechanical powers. The earlier generations did—the latter explained how it had been possible to do so—art was the mother of science—the comely mother of a daughter of far loftier and serener beauty. Stimulated by the sight of such massive works of human skill—stimulated still more by the natural working of those powers of man from which such skill had arisen—men were led to seek for science as well as art—for science as the natural complement of art, and fulfilment of the thoughts and hopes which art excites—for science, as the fully-developed blossom of which art is the wonderfully-involved bud."

At the same time it cannot be denied that there is an honourable ambition in the minds of engineers that their names should be, in some degree, associated with works with which they have been connected. I cannot avoid another quotation; this time from the recent publication of a French engineer, M. Vignon, to whose book I am indebted for much of the history of the Corps des ponts et chaussées:—"Many works have left lasting traces and have led to consequences, more useful and more beneficial to the public than certain victories, the glory of which has not sufficed to hide their barrenness. Why not, therefore, name along with the principal engineers, those who have simply aided by their labours, talent, and zeal—as historians willingly record not only the names of generals but those of inferior grade, when they can point out acts worthy of remembrance?" It is not every engineer

"Whose name
History shall blazon on the rolls of fame;"

but he still has the merit of having done his duty, while those who were able to aid him materially "could only have done so by long previous close study, patient self-denial, and intellectual qualifications of will and character, meriting honourable mention for them, when possible, in conjunction with the work of their Chief, as left to the appreciation of posterity."

I now conclude:—thanking you for the attention with which you have followed me through this protracted address, which I regret to have been unable to compress within more reasonable limits.

INSTITUTION OF MECHANICAL ENGINEERS.

CAPT. NOBLE'S INSTRUMENT FOR DETERMINING THE VELOCITY OF PROJECTILES IN DIFFERENT PARTS OF THE BORE OF A GUN.

The object of this instrument is to render distinctly visible and to register the exceedingly minute intervals of time occupied by the passage of a shot through successive distances in the bore of a gun; and this is effected by registering these intervals of time, by the aid of electric currents, upon a recording surface travelling at a uniform and very high speed, so that the minute intervals of time are represented by intervals of space that are of sufficient magnitude to be readily appreciable. The instrument consists of two portions: first, the mechanical arrangement for obtaining the extremely high speed of the recording surface, and maintaining that speed uniform; and second, the electric apparatus for registering upon this surface the exact instants of time at which the shot passes certain stated points in the bore of the gun.

The first part of the instrument, for obtaining a very high and uniform speed of the recording surface, consists of a series of six thin metal discs, each 36in. circumference, fixed at intervals upon a horizontal revolving shaft, which is driven at a very high speed by a heavy descending weight, arranged according to a plan originally proposed by Huyghens, through a train of gearing multiplying 625 times. If the speed of rotation of the discs were got up through the action of the falling weight alone, a very considerable waste of time would be occasioned; and to obviate this inconvenience a special arrangement is provided for obtaining approximately with great rapidity the required velocity of the discs, by means of a handwheel connected temporarily with the gearing. The sound emitted by the rapid rotation of the discs and gearing serves as an indication of the uniformity of speed, a very slight variation in speed being sufficient to alter the acuteness of the sound to an extent that is readily detected by the ear. The actual velocity is ascertained by a clock connected with one of the slower wheels of the train; and the time of making each five revolutions of this wheel, or 625 of the discs, is shown correct to 1-10th of a second by the clock. The speed usually employed in the working of the instrument is about 1000in. per second lineal velocity at the circumference of the revolving discs, so that each inch travelled at the circumference of the discs at that speed represents one thousandth part of a second; and as the inch is subdivided by a vernier and magnifying eye-piece into a thousand parts, a lineal representation at the circumference of the discs is thus obtained of intervals of time as minute as one millionth of a second. As a minute variation in speed would make a difference in measurement at the circumference of the discs, the uniformity of rotation maintained by the descending weight is tested on each occasion of experiment by three observations, one immediately before, one during, and one immediately after the experiment, the mean of these being taken for the average speed during the experiment. With a little practice there is no difficulty in arranging the instrument so that the discs may rotate either quite uniformly or at a rate very slowly increasing or decreasing; and it is found that the probable error then arising in the determination of the time occupied by 625 revolutions of the discs rarely amounts to so much as 1-10th of a second, the total time of making each 625 revolutions being about 23 seconds. The uniformity of revolutions during each experiment may consequently be considered practically perfect, as the total time of observation in the passage of a projectile along the length of a gun is generally less than one third of a single revolution of the discs. The maintenance of the speed with so great a degree of uniformity is obtained by means of very great accuracy of workmanship in all parts of the mechanism.

For accomplishing the second portion of the operation, namely, the registering of the exact instants of time which it is desired to determine, the six revolving discs are each covered on the edge with a strip of white paper, and are all in connection with one extremity of each of the secondary wires of six electrical induction coils; the other extremity of each secondary wire, carefully insulated, is brought to a discharger opposite the edge of its corresponding disc, and is fixed so as to be just clear of the revolving disc. When an electric spark is passed from one of the wires to its corresponding revolving disc, a minute hole is perforated in the paper covering on the edge of the disc, marking the point of the disc that was opposite to the wire at the instant of the spark passing; but as the situation of this hole in the paper would be very difficult to find on account of its extreme minuteness, the paper is previously blackened over with lampblack, and the position of the hole is then readily seen by a distinct white spot being left on the blackened paper on the edge of the disc, in consequence of the lamblack at that point having been burnt away by the electric spark, so that the white paper is shown beneath. As the points of the six wires at the edge of the disc are all arranged in the same horizontal straight line, parallel with the axis of the revolving discs, an absolutely simultaneous passage of the six electric sparks causes the spots produced upon the six discs to be all exactly in the same horizontal straight line, at whatever speed the discs may be revolving; but any interval of time between the sparks is represented by a corresponding circumferential distance between the spots on the different discs, this distance being proportionate to the speed at which the discs are revolving. Thus when the discs are running at the circumferential speed of 1000 inches per second, an interval of 1-1000th part of a second of time between any two of the sparks causes the spots made upon the two corresponding discs to be separated by a distance of 1 inch measured at the circumference of the discs.

The mode of connecting the primary wires of the induction coils to the bore of the gun, in such a manner that an electric current shall be induced and a spark produced at the instant of the shot passing each wire in succession, is shown in Figs. 1 and 2, representing a longitudinal and a transverse section of the bore B of the gun, along which the shot A is moving in the direction of the arrow. A hollow plug C is screwed into the side of the gun, carrying at its inner extremity a hinged finger D, forming a trigger, which is made at an incline at the tail end, projecting slightly within the bore of the gun, as shown on the right hand side in Fig. 1 and in Fig. 2; and the trigger is held up in this position by the primary wire, which passes in at one side of the plug C, then through a hole in the trigger D, and out again at the other side of the plug. When the shot is fired, it presses the trigger D outwards, as shown on the left-hand side in Fig. 1, and thereby cuts the wire through; and the consequent breaking of the current in the primary wire induces a current instantaneously in the secondary wire, causing an electric spark at the same instant to pass from the point of the wire to the disc, its passage being marked by the spot left upon the paper edge of the disc.

The action of the apparatus was exhibited by Captain Noble by firing a shot from a musket, the bore of which was connected with the six discs of the instrument by six wires arranged at increasing intervals along the length of the barrel; the distances between the successive wires, commencing at the breech end, ½ inch, 1½ inch, 3 inches, 5 inches, and 7½ inches. At the instant of firing the six sparks were seen to pass at the edge of the discs, all apparently at the same moment; but on stopping the rotation of the discs, it was seen that the spots left by the passage of the sparks were situated at increasing intervals round the circumference of the successive discs, extending to a distance of about 2 inches, the visible intervals of space being exactly proportionate to the minute intervals of time occupied by the shot in passing through the successive intervals in the bore of the gun. For the purpose of illustrating the correct action of the instrument, a second experiment was exhibited with all the six wires placed together across the muzzle of the gun, so that the shot when fired should sever

FIG. 1.

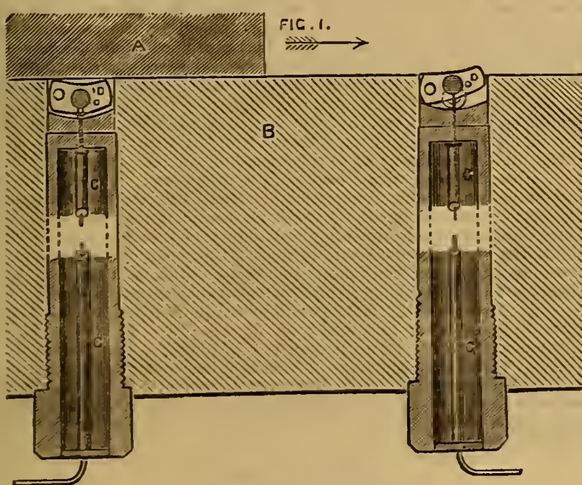
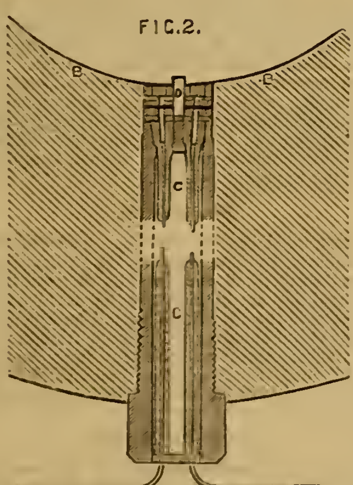


FIG. 2.



them all simultaneously. The discs were then made to revolve at the same speed as in the previous experiment, and the shot was fired; and on stopping the discs, the six spots made by the passage of the sparks were found to be all exactly in the same horizontal straight line, parallel with the axis of the discs, showing that the six sparks had all occurred at precisely the same instant of time, and that there was consequently no irregularity in the instrument from inequality in rate of transition of the electric currents by the six separate wires.

The instantaneous action of the electric currents obtained by the use of an induction coil admits of the observations being taken by means of this instrument at very short intervals along the bore of the gun; and as many as six observations have been obtained in this way in a length of only 9in. along the bore. In the first trials of this instrument three years ago, it was attempted, on account of the expense of induction coils, to employ electro-magnets for recording on the discs the moment at which the current of electricity was broken by the passage of the shot. In this arrangement a pointer pressed towards the revolving disc by a strong spring was held back just clear of the disc by means of a powerful electro-magnet; and when the current of electricity was broken, the magnet becoming de-magnetised released the pointer, which registered by a scratch on the prepared surface of the disc the moment of the shot passing. By this means tolerably accurate results were obtained, as long as it was attempted to work with two discs only; but even with two discs considerable irregularities occurred in the results, owing apparently to almost inappreciable variations in the strength of the electric currents; in spite of these difficulties however, the velocities at different points of the bore of a Lancaster rifle were determined with tolerable accuracy. But when it was attempted to use more than two discs, the irregularity of action of the instrument was so great that this mode of registration had after many trials to be abandoned, and the induction coils were adopted instead.

In order to measure the circumferential distances between the spots marked on the successive discs in any experiment, the shaft of the revolving discs is disconnected from the gearing of the instrument; and by means of a micrometer screw each disc in succession is then turned backwards until the spot upon its edge is brought exactly opposite a magnifying eye-piece, which slides horizontally along a bed parallel to the axis of the discs. The divided head of the micrometer screw shows the circumferential distance through which each disc is turned backwards, which is then recorded; and by setting out in the form of a diagram the circumferential distances thus determined between the spots marked upon the successive discs, a "time" curve is obtained, as shown by the strong dotted lines in Figs. 3 and 4. The position of the vertical lines

FIG. 3.

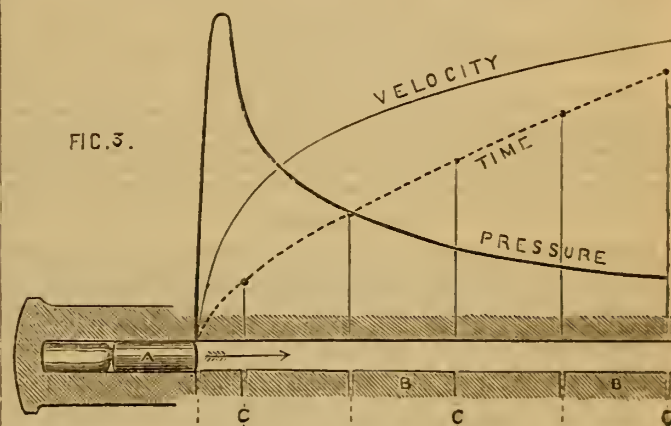
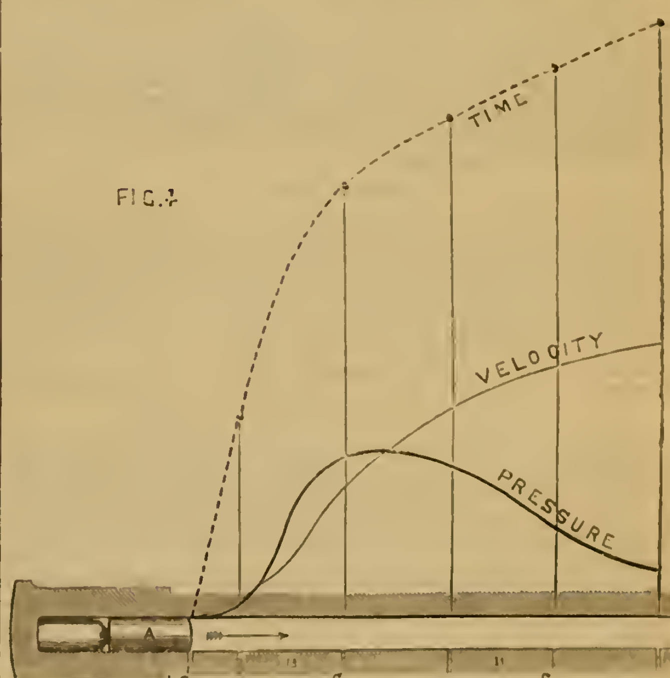


FIG. 4.



represents the position of the six wires fixed at successive points C C along the bore of the gun B; and the vertical length of each line, being the circumferential distance of the spot on the corresponding disc, represents the time occupied by the shot A in reaching the corresponding point in the gun from the moment of starting. From the "time" curves are obtained by calculation the "velocity" curves, shown by the fine lines in Figs. 3 and 4; and from these again the "pressure" curves, shown by the strong full lines, are also arrived at by calculation.

The practical application that has been made of this instrument has been for the purpose of ascertaining the relative strains to which guns are subjected by the employment of different sorts of gunpowder, fast-burning and slow-burning; and the curves shown in the diagrams Figs. 3 and 4, are some of the actual curves that have been obtained in the experiments made upon this subject. In Fig. 3 are shown the curves given by a fast-burning powder, and in Fig. 4 those obtained with a slow-burning powder; and a comparison of the two shows that in this instance, although the shot took about twice as long time in passing along the length of the bore of the gun when fired by the slow-burning powder, yet the velocity at which it left the muzzle of the gun was about the same as when fired by the fast-burning powder; while at the same time the important advantage is here gained with the slow-burning powder that the maximum strain thrown upon the gun in firing is only about half of that to which the gun is subjected in firing the same shot with the fast-burning powder.

INSTITUTION OF ENGINEERS IN SCOTLAND.

INTRODUCTORY REMARKS.

By The President, Professor W. J. Macquorn Rankine, C.E., LL.D. F.R.SS.L. & E., F.R.SS.A., &c.

Gentlemen,—Called unexpectedly as I have been by the Council of this Institution to fill, until the next election, the chair left vacant by my distinguished and lamented predecessor, it is impossible for me to lay before you, as he would have done had his life been spared, a comprehensive and systematic view of the progress of engineering and the kindred arts. I can only offer you some remarks on particular departments of that subject, in the order in which they occur to me.

Steam Navigation.

Naturally, the first department to suggest itself is that of steam navigation, for the advancement of which our late President and his firm did so much. I will not now enter into details respecting the principles which they applied, and their methods of carrying those principles out; for these will form an important part of the subject of a memoir of Mr. John Elder, for which the Council are now collecting materials. I will only state, that the practice of marine engineers in general at the present time is characterised by an extensive and increasing application of the means of realising the best economy of fuel and of power in marine engines; such as the augmentation of the heating surface of boilers, and its arrangement in the most efficient way; the heating of the feed water; the superheating of the steam; the use of steam at high pressures in condensing engines; the use of high rates of expansion, combined with the means of realising their proper economy, by preventing the liquefaction of steam in the cylinder; the use of surface condensers; the arrangement of mechanism so as to diminish friction; the application of governors to marine engines, with a view to safety as well as to economy. To these we may add, as a practice which has not quite passed the experimental stage, but which promises to have good results, when employed with proper precautions, the use of liquid fuel in marine engines, in order to effect a considerable saving of weight and stowage-room on long voyages.

Measured Mile.

The means available on the Clyde for ascertaining with precision the performance of steam vessels, have of late been much improved by the marking, by Messrs. R. Napier and Sons, of a measured mile on a part of the Firth where the tidal currents run straight and regularly. There are purposes, such as the testing of the economy of fuel, for which the longer distance between the Cloch Lighthouse and the Cumbrae Lighthouse is very useful; but for accurate comparisons of power with speed in tidal waters, a series of three runs back and forward is absolutely necessary, and one of from four to six runs and upwards is desirable, if practicable: and to accomplish such series without great expenditure of time, it is necessary to have a short distance very accurately marked.

Committees of the British Association on Ships.

With a view to the reduction of marine steam engineering and shipbuilding to general principles, a Committee of the British Association was engaged for about seven years, from 1857 to 1863, in collecting and publishing statements of the performance of steam ships, compiled from information furnished to them by the Admiralty, by steamboat owners, by shipbuilders, and by marine engineers. The tables and reports published by that committee contain details of the dimensions and performance of about 270 vessels, and are of so great a bulk as to be very inconvenient for reference; and a second committee was appointed to condense them into a moderate bulk, and to arrange and analyse their results, with the addition of such further information as might in the meanwhile be obtained. The reports of the second committee were presented to the British Association in 1867 and 1868, and have been printed and published, except a small portion which will appear in the Transactions of that body for 1869.

The Association, in 1868, appointed a third committee, for the purpose of reporting on the State of Existing Knowledge of the Stability, Propulsion, and Sea-going Qualities of Ships; and the first report of this third committee was presented to the Association in 1869. After giving a summary of existing knowledge as to the stability and resistance of ships, the committee point out the want of certain experiments on those qualities, which ought to be made on a scale so great as to be beyond the means either of individuals or of scientific societies; and they recommend that the importance of making such experiments at the public expense be represented to the Admiralty. The committee also recommend, that the co-operation of the Institution of Civil Engineers, the Institution of Engineers in Scotland, and the Institution of Naval Architects, be sought, in applying to the Government, and otherwise carrying out the views of the committee; and they have made a communication to the Council of this Institution, which will, as soon as practicable, be laid before you for consideration.

Experiments on Model Boats.

One of the members of the committee just mentioned, Mr. William Froude, has now in progress some experiments on the resistance of model boats, in the course of which he has obtained results of a kind so curious and paradoxical, that it may be interesting to this meeting to hear a statement of their general nature. The model boats were of three lengths, of 3, 6, and 12ft.; and in each case two models of equal displacement and equal length were compared together; the water-line of one was a wave-line, with fine sharp ends; that of the other had rounded ends, and was of a figure suggested to Mr. Froude by the appearance of water-birds when swimming. At low velocities, the resistance of the sharp-ended model was the smaller; and that continued to be the case up to a speed nearly agreeing with the greatest economical speed corresponding to the given length, according to Mr. Scott Russell's rule; at that speed, the resistance of the two boats became equal; at higher speeds, the resistance of the round-ended bird-like boat was the less; and it showed an advantage in that respect over the sharp-ended boat, increasing rapidly with the excess of speed beyond the limit fixed according to the wave-line system. Applying the principle, that when the respective velocities of a model and of a ship of similar figure are proportional to the square roots of their lengths, the resistances are proportional to the displacements, Mr. Froude considers that the results of his experiments may very probably be applicable to vessels on the large scale. For example, if the resistances of a pair of models 12ft. long, and of equal displacement, be found to bear a certain proportion to each other at a speed of $3\frac{1}{2}$ knots, then the resistance of a pair of ships of equal displacement, similar to the models, and $12 \times 16 = 192$ft. long, will probably be found to bear the same proportion to each other at a speed of $3\frac{1}{2} \times \sqrt{16} = 3\frac{1}{2} \times 4 = 14$ knots. Should these anticipations be realised on the great scale, they may lead to important modifications in the lines of vessels intended for high speeds. It is easy to see what advantages might be gained in point of strength, durability, economy of material, stowage, and liveliness, if the bow of a ship intended for a high speed could be rounded, even to a small extent, consistently with economy of propelling power.

Ejector-Condensers.

The most important improvement that has lately been made on steam-engines in general, is the introduction of apparatus whereby the combined impetus of the currents of exhaust steam and of injection-water is made use of to eject the products of condensation, and so to supersede the air-pump, well-known to be one of the most troublesome parts of the steam engine. This improvement enables condensation to be used in many engines in which it never was applied before; such, for example, as the small separate engines now often used in factories to drive various machines, instead of the former system of transmitting power by lines of shafting; and it possibly may have ultimately the effect of putting an end to the use of non-condensing engines, except where the exhaust steam is needed in order to produce a blast.

Fire Engines.

For some years past rapid progress has been made in the improvement of portable steam fire engines. In these machines the quality of the first importance is the rapid raising of steam; and next in order is great boiler power in small space. Both these qualities are obtained by the use of numerous water tubes exposing a great surface to the fire within a small bulk, and so constructed and arranged as to let the steam bubbles readily escape from them. In some recent examples steam of 100lbs. pressure on the square inch above the atmosphere is raised in about $7\frac{1}{2}$ minutes. Freedom from vibration and great steadiness of jet have been obtained by using three steam cylinders whose pistons work three double acting pumps.

Locomotive Engines.

It is well known that in locomotive engines the use counter pressure, effected by putting the slide valves in backward gear while the engine is moving ahead, is a most convenient means of preventing acceleration on descending gradients, slowing or stopping the train, and generally doing the duty of a brake. When first introduced, however, it was liable to the serious objection that it caused hot air and ashes to be drawn from the chimney into the cylinders and forced into the boiler, to the great injury of the piston, valves, and other parts of the engine. A method of preventing that evil has been, with perfect success, introduced by M. Le Chatelier; it consists mainly of admitting from the boiler into each of the exhaust pipes, when working at counter-pressure, a small quantity of liquid water, sometimes alone, sometimes mixed with more or less steam; this expands into steam of atmospheric pressure during the forward stroke of the piston, so as to fill the cylinder and ports, and partly to escape at the blast pipe, thus preventing the entrance of hot air and ashes. That steam, during the return stroke, is compressed until it rises to the boiler pressure, and forced back into the boiler; and during that process it exerts the resistance required in order to give brake-power. A screw and winch for adjusting the link-motion, as in some marine engines, have in many locomotive engines been substituted for the lever or reversing handle formerly employed. This at once prevents the danger to the engine-driver arising from the tendency of the link-motion when working at counter-pressure, to fly suddenly into forward gear, and enables the grade of expansion to be adjusted with greater precision than is possible when the lever is used.

Traction-Engines.

The most remarkable recent improvement in road locomotives, or traction-engines, is Mr. R. W. Thomson's adaptation to their wheels of india-rubber tyres; in some examples twelve inches broad and five inches thick. These appear to be suited alike to all sorts of ground, hard and soft, rough and smooth; pavements, broken stone, and ploughed fields. They prevent slipping and jolting, and lessen resistance; and they specially facilitate the use of the engine for agricultural purposes.

Agricultural Machinery.

As regards the application of machinery to agriculture, the present time is marked rather by the increased use of previously existing machines, and by improvements in detail, than by the introduction of any new principles. Ploughing by steam power, in particular, is every year being more extensively practised. For information on this subject, reference may be made to a paper by Mr. Baldwin Latham, in the Transactions of the Society of Engineers for 1868–9

Reaping Machines.

One novelty in point of principle may be noticed in the construction of reaping machines. It is the invention of Mr. J. A. Douglas, and consists in fixing the triangular knife-blades to an endless chain, which travels continuously, instead of to a bar having a reciprocating motion. It is obvious that this improvement, by lessening vibration, must at once save motive power, and increase the durability of the machine.

Increasing Use of Steel.

In the construction of machinery in general, we have to remark the progressively increasing use of steel instead of iron, arising in a great measure from the invention of processes by which large masses of steel can be made at a moderate price. The advantage of this change of material is most decided in the case of pieces of large dimensions, such as the propeller shafts of powerful steamers; for it is in such pieces that it is most difficult to obtain with certainty large iron forgings free from flaws and from local weakness.

Scientific Construction.

In works of civil engineering, specially so called, we may remark the effects of the more extensive diffusion of knowledge of the scientific principles of construction. In the bridges and viaducts, for example, which now occur on new lines of railway, we generally see that the material is arranged so as to resist, in the most efficient and economical manner, the straining action of the load, by being concentrated along the lines of most severe stress.

Narrow Gauge Railways.

A class of railways well deserving of attention are those of which the now well known Festiniog Railway is perhaps the first example:—railways of extremely narrow gauge, say from 2ft. to 3½ft., suited to districts where the traffic is not sufficient to yield a profit on a line of a wider gauge.

Machinery used in Tunnelling and Earthwork.

In the execution of great lines of communication, labour saving processes are employed, without which many works now successfully advancing towards completion would have been impracticable. Amongst such processes may be classed those employed in excavating by machinery the great tunnel through the Alps, and the use of the transporting power of water in removing the material excavated from the Suez Canal.

Abrading and Transporting Power of Water.

The abrading and transporting power of water for earthy matter is one of those subjects on which additional experimental knowledge is much wanted. It has been pointed out by Mr. Thomas Login, C.E., of the Public Works Department of India, that not only has a current of water of a certain velocity a certain power of sweeping along solid material, but that its power of picking up and carrying off additional solid matter, by abrading or scouring away the bed, is diminished by the fact of its already holding solid matter in suspension; and that when it is, so to speak, saturated with solid material, its power of abrading additional solid material is gone. Precise data are still wanting as to the transporting power of currents at different velocities, and as to the abrading power of currents at different velocities, and holding in suspension different proportions of solid matter. To obtain such data, experiments would be required on a scale beyond the means of individuals or of scientific societies; and considering the great practical importance of an accurate knowledge of this subject to drainage, irrigation, and inland navigation—matters affecting the interests of the whole British empire, but especially of its Indian provinces, it appears to be well worthy of consideration whether such experiments should not be made at the public expense.

Sand Concrete.

It has long been known how greatly the execution of breakwaters and other harbour works and sea defences is facilitated by the use of blocks of concrete instead of natural stones; because such blocks can be made of any size that may be required in order to resist the force of the waves. It has lately been shown by the mode of construction used in the breakwaters of Port Said, at the northern end of the Suez Canal. that such concrete may be made of hydraulic lime and sand alone, without gravel or stones.

Sanitary Engineering.

In sanitary engineering, the most advanced branch is certainly that of water supply, which depends almost wholly on simple and definite mechanical principles. In many cities, however, it is obviously necessary that measures should be devised to prevent the waste of water. That subject was brought before this Institution last session. As regards the drainage and cleansing of towns, questions have arisen which are beset with difficulties; but those difficulties are, properly speaking, not so much of an engineering as of a physiological and social character. Let the community decide what they wish to be done with the refuse of a great city, and engineers will easily be found to design and execute the requisite works.

Ventilation.

A branch of sanitary engineering not less important than water supply and cleansing, is ventilation; but its difficulties and imperfections are in some respects of an opposite character. In the branch which deals with liquids and solids, we find that the supply of pure water is comparatively easy, while the removal of refuse involves matters of dispute and perplexity. In the case of ventilation, on the other hand, appliances for the removal of foul air are well known and extensively used; while the supply of fresh air, though in some cases efficiently provided for, is in other cases neglected; and there are too many instances of the latter class. We too often see large and splendid public halls, in which outlets for foul air have been most carefully planned and executed at various points of the roof, while the supply of air has been left to the casual opening of a door, or to the currents which the pressure of the atmosphere may cause to enter through drains and soil pipes, or down disused chimneys. There are many exceptions, however, to this remark to be found in buildings where the supply of fresh air has been amply and skilfully provided; and the number of those exceptions is fortunately increasing. Care should be taken not to under-estimate the supply of fresh air required by the inmates of a building; experience has proved that each individual requires at the very least 20 cubic feet per minute, and that if possible he should be supplied with 30.

Patents for Inventions.

The efforts which from time to time have been made to procure the abolition of patents for inventions have of late been renewed with much vigour and ability, and with equal vigour and ability resisted. The arguments on both sides are well known, and there is only one of them of which I shall remind the institution on the present occasion; because it is one which, though brought forward some years ago, has latterly been somewhat overlooked. It is this: those who object to the recognition of property in ideas, must, in order to be consistent, virtually object much more strongly to the recognition of all other kinds of property; for property in ideas is the only property that is absolute, and not founded on legal or social convention. It is possible by law, or by force, to take from a man all material objects which he may claim, and even the labour of his body: the only possession which is absolutely and unconditionally his own, and of which he cannot by any human power be deprived against his will, is the labour of his mind. Its fruits cannot be obtained from him honestly, except for a price satisfactory to him, or as a free gift on his part. Hence, property in the fruits of mental labour is the truly real property, and the foundation of all other kinds of property, and of all forms of value.

I will also refer to a question of fact as to which it appears to me that the opponents of the granting of patents are mistaken. They allege that the idea of almost every useful invention occurs to several persons nearly at the same time; and that to grant a patent to one of those persons because he happens to be the first to undertake the publication of the invention, is to deprive for a certain number of years the actual or potential inventors of their fair share of the benefit. But from long continued observation of the progress of invention I am convinced, that although the general principle of a class of useful inventions may, and very often does occur to many men at once, such is not the case with methods of carrying that principle into effect; but that in almost every instance, the methods of practical application which occur to the mind of independent discoverers of the same general principle, are varied sufficiently to enable those methods to be considered as separate inventions; so that the granting of a patent for one of them will not injuriously impede the use of the others. I do not remember any instance of alleged identity of independent inventions in method of application, as well as in general principle, in which an inquiry failed to prove, either that the alleged identity did not exist, or that if it did exist, it was the result of copying. It is well known that a patent is never granted for a general principle, but only for a method of applying a principle to a practice.

Engineering Education.

The movement which is now so active for the extension and improvement of technical education, is one in which the members of the various branches of the engineering profession are deeply interested. The objects carried out by those who promote technical education may be classed under four heads: providing teachers; providing buildings; providing the materials of instruction and providing scholars. A step was made by the Government about thirty years ago towards the providing of teachers of the scientific principles of engineering, by the founding of chairs of civil engineering and mechanics in some Universities; amongst others that of Glasgow. The efforts of the holders of those chairs met with but partial success, until their teaching was made to form the conclusion of a systematic course of instruction in the various sciences bearing on engineering; after that systematic course had been established, the students steadily increased in number, diligence, and ability. More recently much has been done to increase the number of teachers, and I may mention, as specially worthy of honour, the establishment by the Government of the Royal School of Naval Architecture and Marine Engineering; the contributions of the inhabitants of Manchester towards the endowment of Owen's College; and the foundation, in the University of Edinburgh, by Sir David Baxter, with aid from the Government, of the most liberally endowed chair of Civil Engineering in the United Kingdom. As regards the provision of buildings, I know of no instance of munificence to be compared to that of the inhabitants of Glasgow and its neighbourhood. The amount of their subscriptions to the funds for the new University buildings, taken together with the Government grant and with other resources, has enabled that building to be executed on a scale which will provide most ample and convenient accommodation for the engineering department, as well as for other branches of study, which have hitherto been conducted, in the old college, under great disadvantages as to space, light and air.

The objects which give the most important aid to instruction in engineering science are those examples of materials and workmanship which are to be seen in actual structures and machines. Nevertheless, a good collection of specimens of engineering materials would be of great service in connection with the engineering department of an University; and so also would a collection of models, drawings, and instruments, though less important than specimens of materials.

It is only necessary to name to you Sir Joseph Whitworth, in order to remind you of the magnificent endowment which he has provided for students of mechanical science and practice combined.

It is evident that the value of scientific education to engineers is at the present day duly appreciated, and that the means of obtaining it are being rapidly extended, and indeed are in many cases promoted with enthusiasm. Just as in every similar case, in which a good object is earnestly pursued, there are errors against which it is necessary to guard. One is, to expect results from the scientific branch of education which it is not really capable of accomplishing. The purely practical parts engineering, such as the use of tools, and the superintendence of works, cannot be soundly and thoroughly learned except through experience in real business; and it is a mistake to endeavour to teach them during an University course. The true laboratory for students of engineering science is to be found in the workshops of such cities as Glasgow, and amongst the earthwork, masonry, carpentry, and ironwork of engineering structures in progress.

I have to congratulate this institution on the recent conferring of hereditary rank on two of our honorary members: Sir William Fairbairn and Sir Joseph Whitworth—an act which has done honour not only to those great engineers and men of science, but to our Sovereign and her advisers, and to the nation.

PATENT LAW.

The Bovill Litigation.

(*Continued from page* 19.)

"As regards the other cases I have had them before me before. What Mr. Little says is quite true, that I am bound to go by the evidence in this case alone, and not to attend to any other, but I only say, I have had it before me before, for this reason that it shows that the parties have had the opportunit of making the very best case they can. Therefore having all been tried before, I must assume, that the best has been done that could be done to strengthen it. Now as to Muir's case, I have it in evidence, and I have a right to look at it as part of the *res gestæ* in Bovill v. Keyworth. Mr. Muir was called in Bovill v. Keyworth, and merely gave the same evidence as he gives here, with the exception that in cross-examination he was a good deal broken down. In his examination in chief he says exactly the same thing, as to his having got the drawings at Altona, and so on—he tells exactly the same story as he told before. Now what does Mr. Muir say now, in order to strengthen the case? Mr. Muir now says this, and it is a most remarkable statement, and it is really a very strong illustration of the difficulty in which a patentee is placed when after he has succeeded in case after case, persons still go on fighting it eighteen years after the date of the patent. Here is Mr. Muir when his memory was comparatively fresh in 1857, telling this story; now ten years more have passed, telling the story that he told then in his examination in chief, but which in cross-examination was a good deal broken down and ultimately his case cannot have been believed, because if it had been believed it would of course have been forestalling of the plaintiff's patent. He says this: 'My aforesaid letter to Robert Gordon of 23 February, 1849, was produced on the trial in 1856 in the cause Bovill v. Keyworth and Seeley, and my machine copy thereof was made an exhibit on the occasion of my being sworn to my affidavit in Bovill v. Goodier. I am aware that on my being examined as a witness in the said cause of Bovill v. Keyworth and Seeley, and in my said affidavit in Bovill v. Goodier and several other affidavits, I have made in causes relating to the plaintiff's patent, as well as upon my being examined as a witness upon the trial of the issues in Bovill v. Goodier, I did not state the various dates and circumstances in accordance with what I have hereinbefore stated.' Well now, how is this case launched? A man tells you in that case of Bovill v. Keyworth ten years ago, again in Bovill v. Goodier, and in several other affidavits he has made he has not stated things as he now states them in year 1867. What excuse does he give for it, how does he explain the differences? Why, he adds this, 'I have been led by the difficulty I experienced, with regard to them whilst I was under cross-examination, to investigate them narrowly and to refresh my memory by reference to my books and correspondence of the period, and having done so, I say that the foregoing statements of what was done at the Tradeston Mills, are all untrue.' Now, observe what this gentleman has been reduced to say. He says he experienced difficulty under cross-examination, that is when he was cross-examined in Bovill v. Keyworth, two years ago, and then made a great number of statements not in accordance with his present statement, but since Bovill v. Keyworth, and since these difficulties occurred to him, he has made several other affidavits in the case of Bovill v. Goodier, and other causes in which the plaintiff has proceeded, and although he knew he was going to pledge his oath to the facts, he never thought of looking at his books, papers, or writings until this case came on. He has gone on making repeated misstatements, he had the difficulties brought before his mind in the former case; he goes on swearing, as he says himself, in that way, and never thinks of looking at the books and papers which he looks at for the purpose of this suit. I had really better refer to his affidavit and use his own words, for it is indeed difficult to exaggerate what is put down in those words. He says, 'I am aware that on being examined as a witness in the said cause of Bovill v. Keyworth and Seeley, and in my said affidavit in Bovill v. Goodier, and several other affidavits I have made in the causes relating to plaintiff's patent, as well as upon my being examined as a witness upon the trial of the issue in Bovill v. Goodier, I did not state the various dates and circumstances in accordance with what I have hereinbefore stated.' Neither before he was to be examined as a witness, before he made the affidavits in Bovill v. Goodier, nor before he made the several other affidavits in the other causes, did he think it worth his while to be sure in the truth to which he was about to swear as between the parties who were engaged in the litigation, and during all these years never once, until this moment, did the happy idea occur to corroborate his story or refresh his memory by reference to his books and papers. How can I believe such evidence as that? It is utterly impossible that I can regard it for a single moment. Then Woods is called, whom I had not heard of before, and Woods comes forward to corroborate these statements, and make out what, if true, would be a prior invention to the plaintiff's patent. Woods himself is not cross-examined, but there is produced from him a letter; it has been admitted; he was not required to be called to prove it. There is a letter written just after the trial of Bovill v. Keyworth was over, when everything was fresh in his mind, to Mr. Don, the plaintiff's agent, in which Woods congratulates him on his success—says that Mr. Muir must think very little of himself after the comments which were made by the Chief Justice upon his evidence, and saying he hopes they will take proceedings in Scotland as well as in England. This is the man who is to corroborate Mr. Muir, now, who when the thing was fresh in his mind, writes this letter, and says he was satisfied and convinced upon the subject, speaking of the figure which he cut then, and which I think Mr. Muir cuts upon this occasion, a very poor figure indeed; a man makes this statement upon his oath, he has his attention called to the subject, he goes on making misstatement after misstatement, and does not until after the sixth, seventh or eighth affidavit made in the cause, think it worth his while to look at those things which he now says gives him confidence and assurance. Well, I do not think it necessary to say more upon that part of the case.

In order that our readers may appreciate the accuracy and even fairness of the Vice-Chancellor's version of Mr. Muir's evidence, we give the letter which that gentleman wrote to Mr. Robt. Gordon, in February, 1849 (four months before the date of Mr. Bovill's patent), and also the very words of Mr. Muir's affidavit:—

"Tradeston Mills, Glasgow,
"23rd Feb., 1849.

"Robert Gordon, Esq.

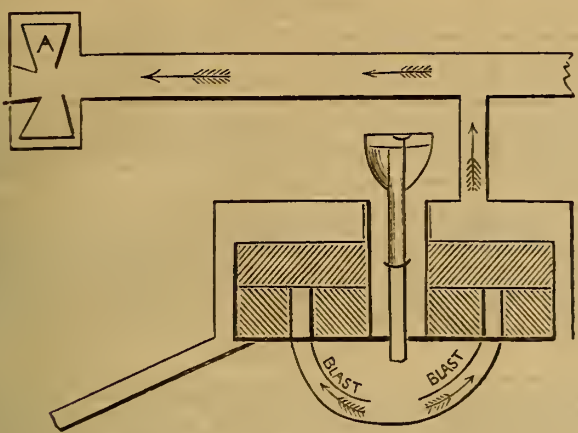
"Dear Sir,—Yours of the 10th is duly received. When I applied your cold blast to our stones, I certainly found it a great improvement, in as far as we were able to grind the flour much cooler and a larger quantity in a given time, &c., but these advantages were certainly counterbalanced by the great waste from dust flying over the mills; I was therefore obliged to shut off the blast shortly after it was in use.

"The improvement that I would suggest will entirely overcome this disadvantage, and otherwise render the application of cold air much more effective; so much so that I am certain with this addition every miller would find it greatly to his advantage to apply your cold blast, which as it is at present is only half complete. This improvement would form a distinct patent, but were it joined with your own, they might be carried out at small expence and advantage to both of us.

"Below you have a rough sketch, with an explanation; but if you could come here in the course of a few days you would see it working to perfection. I have also made some alterations on your cold blast, and the result of both combined I have no doubt will surprise you. Meantime I will be glad to hear from you, and am

"Yours truly,
"Thomas Muir.

"You will observe that the stones are covered in, and made as near as possible air-tight, being supplied with air from the cold blast, which when having passed through the stones is drawn off by the extracting-fan (A), thence into a small room, and into the open air. This room I now consider unnecessary, but may be put up for caution, to allow any dust to subside that may come. I had three of them at first; the extracting-fan runs at the speed of 1,200 ft. per minute."



The Affidavit states:—

"I have been conversant with the business of a corn miller for the last twenty-five years. I and my partners have carried on an extensive business as millers at the aforesaid Tradeston mills ever since the year 1844, and during the whole of that period I have given attention to the various improvements that were introduced in Great Britain and elsewhere in the business of milling. In the year 1847 I visited the mills of M. Lange at Altona, and in the year 1848 I visited the mills of M. D'Arblay at Corbeil. I have since visited America, and I have travelled in various other parts of the continent of Evrope, and have always endeavoured to observe the improvements in milling that were to be met with. In the year 1848 I learned from conversation with M. D'Arblay that he had before then successfully used in his said mills the process of exhausting the stive from the millstone cases.

"In our aforesaid mills we drive thirty pairs of stones. Of these eight pairs are worked with a blast of air into their grinding surfaces, and an exhaust carrying away the plenum thus caused in their cases. The rest of our stones are worked without the combination of the blast and exhaust applied. We consider that such combination is beneficial under some circumstances, but that for many purposes the other arrangements which we have in connection with the twenty-two pairs of stones in our mills are preferable.

"I say that on the 5th day of June, 1849, it was not a new invention to exhaust the air from the cases of millstones combined with the application of a blast to the grinding surfaces of the stones, and that it was not at that date a new invention to strain the stive or air surcharged with fine flour through suitable porous fabrics, which retain the flour and allow the air to pass through, for I say that both those matters had for several months previously to that date been habitually and successfully performed at the aforesaid Tradeston mills as regards four pairs of millstones.

"I say that the following were the circumstances under which the aforesaid processes were adopted in our said mills. We had in the year 1845 applied the cold blast patented in 1844 by Robert Gordon to four pairs of stones therein, and subsequently to three additional pairs of stones. The application of this blast was successful in the primary object of driving air through the grinding surfaces of the millstones, and so making the work of grinding more rapid, but the inconveniences resulting from the blast when there was no suitable provision made for the stive which it would necessarily create were serious, and after trying to obviate the same by enclosing the millstone cases within porous canvas curtains, and otherwise, we were so troubled with the stive that in the year 1846 we discontinued the use of the blast.

"When I visited M. Lange's mill at Altona I found that he was working Gordon's patent blast in a manner completely overcoming the disadvantage which we had found it to entail, and on my return to Glasgow, I proceeded to adopt the same means for using the cold blast successfully, as I had seen used by M. Lange. These means consisted simply in applying exhausting machinery to carry off from the millstone cases the air and stive caused therein by the blast. These means were applied successfully as early as the month of February, 1848, and from that time until the summer of 1852 the same were used constantly, successfully, and publicly in our said mills.

"In the month of February, 1849, after the same had been thoroughly tried and found to answer to our entire satisfaction, I reduced to writing a description of what we were doing at our said mills. This was done in a letter which I wrote on the 23rd of that month to Mr. Robert Gordon, the patentee of the cold blast. I have still a fac-simile copy of such my letter to him, the same being the machine copy or impression taken from the letter itself before it was dispatched. In that letter I described what had been done by me as aforesaid, and was then in use at our said mills, by a drawing of a millstone case and a pair of millstones, showing the cold blast introduced to the grinding surfaces and the modes of connecting the millstone cases with an exhausting machine, and I added a verbal description, which was as follows:—'You will observe that the stones are covered in, and made as near as possible air-tight, being supplied with air from the cold blast, which, when having passed through the stones, is drawn off by the extracting fan (A), thence into a small room, and into the open air. This room I now consider unnecessary, but may be put up for caution to allow any dust to subside that may come. I had three of them at first. The extracting fan runs at the speed of 1200 per minute.' I say that the description mentioned in the aforesaid words in my said letter is a true and faithful description of the process which was then used, and had for some time previously been used by me and my partners at the Tradeston mills aforesaid.

"I say that the rooms and room of which mention is made in my above-quoted letter were of the following kind. So soon as an exhausting fan machine was used, removing away in one channel all the stive from the millstone cases that had formerly descended the meal spout, and pervaded the spout floor, and settled upon the boards of that floor, and upon the machinery therein, whence it was swept up, it was an obvious course to cast it into a room wherein the flour particles contained in the stive might be economised. For this purpose we used originally at our said mills a room of considerable size, say 35 feet by 10 feet, which we divided into three compartments, the first division being of wood, in which a number of holes were bored so as to allow of the passage of air through and beyond it into the second compartment, which was divided from the third compartment by a curtain, which was made of the porous cloth called biscuit sacking. This curtain was secured to the ceiling and sides of the room by nails, and was kept firmly down to the floor by a log of wood being placed upon it for that purpose. The operation of this room was as follows. The exhausting, or, as in my said letter I called it, the extracting fan discharged the stive it sucked from the millstone cases into the first compartment of this room, the area of which was many times larger than that of the trunk or pipe through which the exhausting fan discharged the stive, and by reason of this greater area the stive expanded, and consequently the flour particles were liberated, and a considerable proportion of them subsided upon the floor of this compartment. The stive made its way (in a less dense form) from this first compartment through the holes in the wooden partition into the second compartment. There was no outlet whatever from the first compartment except by the holes in the wooden partition, and there was no outlet whatever from the second compartment (when the curtain was down) except through the pores of the curtain itself. There was, by reason of the fan constantly discharging stive into the first compartment, a very considerable pressure of air in the first and also in the second compartment of this room, and the air under pressure forced itself through the pores of the curtain, but the flour dust was prevented passing through with it, and the stive or air was thus filtered. It was by reason of this curtain being used in our said mills that I have herein stated it was not a new invention on the 5th day of June, 1849, to strain the stive or air surcharged with fine flour through suitable porous fabrics. Before I wrote my said letter of the 23rd February, 1849, to the said Robert Gordon I and my partners had, from observation of the small importance of the flour dust that was collected in the second compartment of the said room as compared with the quantity that was collected in the said first compartment thereof, and also because we found by experience how to regulate the force of the exhaust so as to make it draw off only the extra pressure of air caused by the blast, and therewith the stive, but not to take up any meal, or at all interfere with the descent of the meal down the meal spout, been led to the belief that more than one room or compartment was not required for the efficient working of four pairs of stones with the arrangement of exhaust and blast hereinbefore referred to, but as it was our fixed intention at that time to extend this arrangement to other stones, the compartments were allowed to remain, and when the extensions were made shortly thereafter to three additional pairs of stones, we found that the second and third compartments were again of use.

"I say that the aforesaid blast and exhaust, in combination together, and also the said stive room, continued to be used habitually and without interruption at our said mills up to the summer of 1853. I have lately had occasion to think over very carefully the time and causes at which blast and exhaust in combination ceased to be worked by us, and satisfied myself, and do say that the following is a true descr statement of such time and causes. The steam engine at o had become old, and not of sufficient power to drive all boilers being also worn out to such an extent that steam pressure by about three pounds on the account, as also because the pipes and shaftir n and the stive exhausted from the millstones, and their cases had become imperfect, we shut off in the summer of 1852 both the fan forcing in the blast and the fan exhausting the stive, and we worked the said seven pairs of stones without the blast and without the exhausting, from the summer of 1852, until the end of August, 1853. Shortly before this latter date, we had for the first time introduced fine silk-dressing machines into our said mills, and by adopting these instead of the old wire dressing machines, we effected a very considerable saving of motive power; so much so, indeed, that we were able to resume the use of the exhausting fan in connection with the cases of the said seven pairs of millstones, though not to resume the blast also, and we were then enabled to dress the meal immediately on production through the silk-dressing machines, and we worked the exhaust by itself upon these seven pairs of millstones, along with the silk machines, continuously from that time until the end of the year 1854. At the latter date we (who had been formerly only tenants of the said Tradeston mills) acquired by purchase the interest of our landlords therein, and we then proceeded to erect new and more powerful steam-engines for the same, and to extend and improve our mills generally; and we therefore at that time took down the exhaust appliances, but in the year 1856, when our alterations and improvements of the general arrangements of the mill had been completed, we again applied the blast to the grinding surfaces of eight pairs of millstones, and in combination therewith the exhaust from the cases of those stones, upon identically the same principle as we had used the same from 1848 to 1852, as before stated, and we have ever since continued to use, and do still now use, the said exhaust from the cases of eight pairs of our millstones, in combination with the blast, to their grinding surfaces.

"My aforesaid letter to Robert Gordon of the 23rd February, 1849, was produced on the trial in 1856 of the cause Bovill v. Keyworth and Seeley, and my machine copy thereof was made an exhibit on the occasion of my being sworn to my affidavit in the cause of Bovill v. Goodier. I am aware that on my being examined as a witness in the said cause of Bovill v. Keyworth and Seeley, and in my said affidavit in Bovill v. Goodier, and in several other affidavits I have made in causes relating to the plaintiff's patent, as well as upon my being examined as a witness on the trial of the issues in Bovill v. Goodier, I did not state the various dates and circumstances in accordance with what I have hereinbefore stated, but I have been led by the difficulty I experienced with regard to them whilst under cross-examination to investigate them narrowly, and to refresh my memory by reference to my books and correspondence of the period, and having done so I say that the foregoing statements as to what was done at the Tradeston Mills, and the time when the same was done, and the time and circumstances when and under which its use was suspended and resumed, and the other matters hereinbefore deposed to are the true and correct descriptions and account of those several matters."

REVIEWS AND NOTICES OF NEW BOOKS.

Projet de Construction d'un Tunnel Sous-Marin pour l'établissement d'un chemin de fer devant relier la France a l'Angleterre. Systeme Ernest Martin et Gilbert le Guay, à Randan (Puy-de-Dôme). Paris: Eugène Lacroix.

A brochure detailing the construction and placing of a submarine tube between England and France. The author proposes to construct the tube, which is enclosed in and attached to a square box, open at the top, in sections of suitable length, which are to be conveyed to their position in vessels constructed for the purpose. The mode intended to be adopted for placing them is by means of guide ropes, passing through four eyes or staples, through which two parallel cables pass, which slant from the surface to the bottom of the sea, and down which the portions of the tube are slid into their position. Concrete is then deposited upon the tube in the box from vessels which are to be moored in the requisite position by means of the cables by which the tube and box have been lowered. Over the concrete rubble masonry will be deposited. The inventor depends upon the body of concrete forming a sufficient barrier to the entrance of water in the tube, from which, when completed, the water is to be pumped, and the rails laid. The plan displays great ingenuity in theory, but we fear that the crucial test of experience will demonstrate its impracticability even for a shorter distance than that between Dover and Calais.

Guide Pratique d'Architecture Navale à l'usage des Capitaines de la Marine du Commerce apellés a surveiller les constructions et réparations de leur Navires. Par Gustave Bousquet, Capitaine au long cours, Ingénieur. Paris: Eugène Lacroix.

A little work of the greatest use to shipowners and captains of the merchant navy, for whose use it is especially compiled. It gives a detailed account, with engravings, of the various operations in the construction of vessels (wooden), and contains a quantity of information which everyone in any way connected with shipbuilding will do well to acquire.

NOTES AND NOVELTIES.

MISCELLANEOUS.

Petroleum in India.—The Secretary of the Public Works Department has expressed his opinion that the supply of petroleum which it is expected the salt range will yield will supersede both wood and coal as fuel for the railways of India.

The System of Packing Cotton in America.—Some time ago the Liverpool Chamber of Commerce wrote to the American Chambers urging them to adopt the Liverpool system of packing cotton in place of the existing American system, which makes no allowance for tare and draught. At the meeting of the Council of the Liverpool Chamber on the 29th December a letter from the New York Chamber was read. It stated that a special committee had considered the proposal and had come to the conclusion that no practical good would result from its adoption.

Winter Travelling.—American papers state that every train on the Pacific Railroad has now cars attached with a special supply of fuel, food, lights, and blankets, so that in case of accident, a fight with snow-drifts, or other cause of extended delay, there will be plenty and to spare of everything needed for comfort. It is stated that the Grand Trunk Railroad has a new patent snow plough that has a sweep of 17ft. It throws the snow completely away from the region of the track by means of wings that can be extended at pleasure, which will sometimes throw the snow across the fences. It is made very heavy so as not to be thrown from the track, and has a room and stove inside of it for the men required to manage it.

TRIAL TRIPS.

Trial Trip of the Nile.—The Royal Mail Company's new screw steamship *Nile*, built and engined by Messrs. C. A. Day and Co. at the Northam Iron Works, Southampton, was taken to Stokes Bay for an official trial on the 6th ult. This vessel, the gross registered tonnage of which is 2,994, and builders' measurement tonnage 2,742, is propelled by direct-acting engines of 600-horse power nominal. Her length over all is 376ft. 2in.; length between perpendiculars, 346ft. 9in.; length on load water-line, 340ft.; extreme breadth, 40ft. 5in.; and depth from top of keel to under side of spar deck, 35ft. 7in. She has accommodation for a total of 369 passengers, including 276 first-class berths, and stowage capacity for 800 tons of cargo and 1,200 tons of coals. The *Nile* made four runs at the measured mile, with the following results:—

	Time. H.	M.	Speed.	Steam. Lb.	Vacuum. Inches.	Revolutions.
First run ...	4	13 ...	14·229 ...	24 ...	25½ ...	59
Second run	4	5 ...	14·694 ...	25 ...	25½ ...	60
Third run ...	4	20 ...	13·846 ...	25½ ...	25½ ...	60
Fourth run	3	52 ...	15·517 ...	26 ...	25½ ...	60½

The mean speed of the four runs equals 14·571 knots per hour, superheated steam at cylinders, 320 deg. The machinery worked in the most satisfactory manner throughout the trial, and no trouble whatever was experienced from heated bearings or priming. In proposing the health of the builders, Captain Wilson said he had watched the progress of the *Nile* from the laying of her keel to the present time, and he considered her to be in every respect a beautiful, strong, fast, and faithfully-built ship. The *Nile's* speed at the measured mile is the highest ever attained by any vessel of the Royal Mail Company's fleet. The Peninsular and Oriental Company's steamship *Hindostan*, built recently at the Northam establishment (and which lately arrived at Calcutta in 56 days from Southampton), averaged 14·382 knots on the occasion of her trial trip a few months since.

Trial Trip of the "Albatross."—This new screw steamer recently launched from the building yard of Mr. Key at Kinghorn, and owned by Messrs. G. S. Steater and Co., Leith, made her first trial on the 28th December in the Firth of Forth. Her dimensions are as follows;—Length, 241ft.; breadth, 29ft.; and depth, 22ft. Gross tonnage, 1,030. Her engines, which were made by Mr. Key, are horizontal, direct acting, surface condensing, and of 100 horse power nominal. In steering down the Firth, the propeller revolving steadily at 62 per minute with 30lb. pressure of steam, and 9 cwt. coal per hour, the ship having 400 tons dead weight on board, attained a speed of 9½ knots per hour, by patent log, when going with the tide, and 8¾ when steaming against the tide and a fresh breeze. The steamer is intended for the Leith and general trade, and is commanded by Captain Hewat. The trial trip was considered highly successful and was made under the inspection of Mr. Matthew Anderson, consulting engineer, Leith; and Mr. Caldwell, superintending engineer for the Leith, Hull, and Hamburg Steam Packet Company.

RAILWAYS.

American Railways.—The extent of railway in operation in the United States, at the commencement of 1870, was, according to the best information obtainable on the subject, 48,860 miles. This total does not include 3,500 miles of street railways existing in Boston, New York, Brooklyn, and Philadelphia. In the course of 1869 no less than 6,588 miles of new railway were opened in the United States—viz., in the North-Eastern States, 254 miles; in the middle Eastern States, 1,000 miles; in the South Eastern States, 186 miles; in the Gulf and South-Western States, 223 miles; in the Northern interior States, 3,977 miles; and in the Pacific States, 922 miles. The aggregate expenditure upon United States railways in 1869 was no less than 358,707,678dols. of which 189,000,824dols. related to the Northern interior States. The aggregate amount of capital expended upon United States railways to the close of 1869 was 2,212,412,719dols. The extent of railway in operation in the United States in 1830 was 41 miles; in 1835, 918 miles; in 1840, 2,197 miles; in 1845, 4,522 miles; in 1850, 7,475 miles; in 1855, 17,398 miles; in 1860, 28,771 miles: in 1865, 34,442 miles; and in 1870, 48,860 miles.

The Embankment Railway.—It is stated that in less than three months the Metropolitan District Railway from Westminster-bridge to Cannon-street will be opened. This railway will, when completed, form an important portion of the inner circle system of metropolitan railways, the construction of which was recommended by a committee of the House of Commons with a view to relieve the street traffic. The district line will be seven miles in length from end to end, and is designed to give increased facilities of communication to passengers between the West-end and the City. It is already open from Kensington to Westminster, where it abuts on the Thames Embankment. The section thence to the City was commenced last February, though owing to want of funds the work was delay for six months. Although the section is not quite two miles in length, there are 2,000 men engaged on the works, about 300 being night hands. There are 250 horses, 280 trucks, 130 barges, 20 steam cranes, with three locomotive engines, two of 40 tons and one of 18 tons, daily employed in the various processes incidental in the execution of such an undertaking. The work, with the exception of some 380ft. from Essex-street through the Temple property, is what is known as girder covered way. The tunnel is 25ft. wide and nearly 16ft. high. The first station will be at Hungerford, the second at the foot of Norfolk-street, and the third at Blackfriars. That at Norfolk-street, to be called the Temple Station, will be entirely underground, but all the others are to be built in the open ground, and will be similar in appearance to the structures at Victoria and Paddington. The contractors hope to have the line ready for public traffic as far as Blackfriars, and perhaps Cannon-street, by the 1st of March next.

A Double bogie eight-wheeled 24-ton Fairlie engine, built for the Nasjo and Oscarsham Railway in Sweden, was tried on the 17 ult on the Ring Railway of the Fairlie Engine and Steam Carriage Company at Hatcham. The engine was run round the curves of 50ft. radius, at the speed of twenty miles an hour, with the same ease as the passenger steam carriage, the remarkable performances of which we noted in August last year.

A Railway in Japan.—The project for a railway to Yeddo (Japan) is said to have been revived, and the Japanese Government are in treaty with a Belgian firm for the supply of the necessary plant.

Rolling-Stock Building in Belgium.—The Belgian construction workshops have obtained some important orders of late for engines and machinery. M. Charles Evrard, director of the Belgian General Railway Plant Company, has secured a contract for 400 trucks for the Waronesch and Rostoff line, and 43 locomotives with their tenders for the same line. The number of locomotives in this contract may, not improbably, be increased to 62.

APPLIED CHEMISTRY.

Rendering Commercial Sulphide of Carbon Inodorous.—M. Cloez, states that when sulphide of carbon is left for twenty-for hours in contact with half per cent of its weight of finely-powdered corrosive sublimate, care being taken to shake or stir up this mixture, the mercurial compound combines with the substances which are the cause of the fœtid odour of this substance, and an insoluble compound is deposited. The liquid s carefully decanted, and, after 0·02 of its weight of a pure inodorous fat has been added (no reason is given for this addition), the sulphide is re-distilled with care by the heat of a water-bath. The sulphide thus obtained exhibits an ethereal odour, and is eminently suitable for the extraction of oils, fats, &c., from various substances, since, on evaporation of the purified sulphide, these matters are obtained in as fresh and pure a state as if the oils had been obtained by pressure.

Oxygen Gas for Public Use.—Oxygen gas is now produced on a large scale commercially in Paris. Carts with metal reservoirs containing the compressed gas may be seen in the streets for the supply of consumers. The Gaieté Theatre is one of the largest consumers, the outside being illuminated every night by the oxy-hydrogen light, cylinders of magnesia or zirconia taking the place of those of lime, as ordinarily used for this purpose. The light is interspersed among the gas jets with good effect. In the interior the scenes owe many of their beautiful effects to the use of this light. The oxy-hydrogen light is also used largely for the production of the illuminated advertisements now so common in the Boulevards and other places. These are produced by a magic lantern and screen on the second floors, and the parties undertaking the display of these advertisements are large consumers of the oxygen gas.

Chinchona.—The range of growth of this plant is being rapidly extended. During the Indian Mutiny the enormous price given for quinine at Bombay and elsewhere in that presidency proved the importance of cultivating the chinchona plant in that country, and efforts in this direction have since been attended with remarkable success. A new variety, yielding a larger percentage of quinine than any species yet analyzed, has been discovered by Mr. Broughton, the quinologist to the Madras Government; and it is said to have been raised from seeds collected in the Loxa district of the Andes. About 4,000 chinchona trees have lately been planted in the island of St. Helena, and as the climate is specially favourable and the inhabitants skilful in the management of the trees, there is no reason why this place of call for many of our vessels should not, in this way, supplement usefully her somewhat scanty revenues.

SHIPBUILDING.

Steam Shipbuilding on the Clyde.—Mr. R. Little has contracted with Messrs. A. Duncan and Co., of Port Glasgow, to build a screw of about 1,550 tons register. She will be supplied with compound engines of 200-horse power by the Finnieston Steamship Works, and she is intended for the Mediterranean and American trade. The *Fitzmaurice* screw, has made a trial trip, in which she attained a speed of something over 11½ knots per hour. The *Fitzmaurice* was built and engined by Messrs. Henderson, Coulbourn, and Co., of Renfrew, and they guaranteed a speed of 10 knots per hour. The *Fitzmaurice*, which is owned by Messrs. Swann Brothers, is 190ft. by 25ft. 9in. and 13ft. 7in.,; she has been fitted by her builders with compound surface condensing engines of 90-horse power.

TELEGRAPHIC ENGINEERING.

The Channel cable of the French American Telegraph Company, from Brest to the English coast, has been successfully submerged, and will be brought into operation forthwith.

Mr. Sanger, who has been for many years manager of the Magnetic Telegraph Company in Ireland, has been appointed the manager for that country of the Government telegraphs.

MINES, METALLURGY, &c.

Discovery of Coals in Algeria and Turkey.—According to a statement in the *Echo d'Oran*, it appears that there has been found, near Laghouat, an excellent and abundant seam of coal, near the spot where the ancient Romans worked manganese iron, and zinc mines. As regards the last-named country, M. Hochstetter states that he has found coal near Kézoulik under the carboniferous limestone on the southern slope of the Balkan mountains.

Discovery of an Ancient Silver Mine.—The recent earthquakes in Germany have caused the fall of a large mass of rocks situated between Heidelberg and Wiesloch, and in consequence thereof the works of a silver mine, worked by the ancient Romans, have been brought to light. There is no silver-ore of any importance left, but, instead, a very rich zinc ore is met with in large quantity, which was left untouched by the former workers.

LAUNCHES

Launch of a Turkish Iron-clad.—An addition has lately been made to the Turkish Navy, in the form of a new iron-clad corvette, which was launched from the yard of the Thames Iron Works and Shipbuilding Company. The following are her principal dimensions: Length, 235ft.; breadth, extreme, 42ft.; depth in hold, 19ft. 9in.; burden, 1,601 50-94 tons, builders' measurement; load draught of water, 17ft. 6in. forward, and 18ft. aft, at which she will displace 2,760 tons. She is to be fitted by Messrs. Humphrys and Tennant with engines of 500 nominal horse-power, guaranteed to work up to 3,250, and driving a single screw, from which a speed of at least 13 knots is anticipated. The *Fethi Bulend* is constructed on Mr. E. J. Reed's bracket system of transverse and longitudinal frames, and has been built for the Turkish Government, from the designs of that gentleman, and under Admiralty supervision. Her armament will consist of four 12½-ton Armstrong 300-pounder guns; to be fought only at the corners of the battery in a manner very similar to that adopted by Mr. Mackrow, the naval architect of the Thames Iron Works, for the *King George*, a gun-vessel which was recently built by the company for the Greek Government, and for a corvette for the Turkish Government. The battery of the *Fethi Bulend* is built with sponson sides, similar to those fitted upon the upper deck of the armour-clads of the Invincible class. The armour-plating at the wate line and at the lower part of the battery is 9in. thick; above and below it is 6in. thick apering away fore and aft in the usual style.

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	s.	d.	To £	s.	d.
COPPER.						
Best selected, per ton	73	0	0	75	0	0
Tough cake and tile do.	71	0	0	73	0	0
Sheathing and sheets do.	76	0	0	77	,,	,,
Bolts do.	78	0	0	79	,,	,,
Bottoms do.	79	0	0	80	,,	
Old (exchange) do.	64	0	0	,,	,,	
Burra Burra do.	73	10	0	,,	,,	,,
Wire, per lb.	0	0	10½	,,	,,	,,
Tubes do.	0	0	11½	,,	,,	,,
BRASS.						
Sheets, per lb.	0	0	8½	0	0	9
Wire do.	0	0	8	,,	,,	,,
Tubes do.	0	0	10½	,,	,,	11½
Yellow metal sheath do.	0	0	6½	0	0	7
Sheets do.	0	0	6½	,,	,,	,,
SPELTER.						
Foreign on the spot, per ton	19	0	0	19	5	0
Do. to arrive	19	,,	0	,,	,,	,,
ZINC.						
In sheets, per ton	24	0	0	,,	,,	
TIN.						
English blocks, per ton	,,	,,	,,	111	0	0
Do. bars (in barrels) do.	,,	,,	,,	112	0	0
Do. refined do.	,,	,,	,,	118	0	0
Banca do.	108	0	0	109	0	0
Straits do.	109	0	0	109	10	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	6	6	1	7	6
IX. do. 1st quality do.	1	12	0	1	13	6
IC. do. 2nd quality do.	1	5	6	,,	,,	,,
IX. do. 2nd quality do.	1	11	6	,,	,,	,,
IC. Coke do.	1	2	0	1	3	0
IX. do. do	1	8	0	1	9	0
Canada plates, per ton	13	0	0	,,	,,	,,
Do. at works do.	12	0	0	,,	,,	,,
IRON.						
Bars, Welsh, in London, per ton	7	0	0	7	5	0
Do. to arrive do.	7	5	0	,,	,,	,,
Nail rods do.	7	5	0	7	10	0
Stafford in London do.	8	10	0	9	0	0
Bars do. do.	8	7	6	9	0	0
Hoops do. do.	9	0	0	10	15	0
Sheets, single, do.	9	15	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	0
Bars, common, do.	6	15	0	,,	,,	,,
Do. mrch. Tyne or Tees do.	6	10	0	,,	,,	,,
Do. railway, in Wales, do.	6	12	6	7	0	0
Do. Swedish in London do.	10	2	6	,,	,,	,,
To arrive do.	10	0	0	,,	,,	,,
Pig No. 1 in Clyde do.	2	18	6	3	5	6
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. No. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	10	0	5	15	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pig in London do.	6	0	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	13	15	0	,,	,,	,,
Do. (hammered) do.	14	15	0	15	5	0
Do. in faggots do.	15	15	0	16	0	0
English spring do.	19	0	0	23	0	0
Quicksilver, per bottle	6	17	0	,,	,,	,,
LEAD.						
English pig, common, per ton	18	15	0	,,	,,	,,
Ditto. L.B. do.	19	2	6	,,	,,	,,
Do. W.B. do.	19	10	0	,,	,,	,,
Do. sheet, do.	19	10	0	,,	,,	,,
Do. red lead do.	20	0	0	20	10	0
Do. white do.	27	0	0	30	0	0
Do. patent shot do.	22	0	0	,,	,,	,,
Spanish do.	18	5	0	,,	,,	,,

*At the works 1s to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

WE HAVE ADOPTED A NEW ARRANGEMENT OF THE PROVISIONAL PROTECTIONS APPLIED FOR BY INVENTORS AT THE GREAT SEAL PATENT OFFICE. IF ANY DIFFICULTY SHOULD ARISE WITH REFERENCE TO THE NAMES, ADDRESSES, OR TITLES GIVEN IN THE LIST, THE REQUISITE INFORMATION WILL BE FURNISHED, FREE OF EXPENSE, FROM THE OFFICE, BY ADDRESSING A LETTER, PREPAID, TO THE EDITOR OF "THE ARTIZAN."

DATED DECEMBER 21st, 1869.

3692 H. M. Marsden—Shears
3693 W. E. Gedge—Shearing woven fabrics
3694 W. E. Gedge—Preventing accidents from steam machinery
3695 H. Green—Lubricators
3696 D. G. Fitzgerald—Telegraphs
3697 W. R. Lake—Steel
3698 J. Martin—Rendering woven fabrics waterproof
3699 W. Ferrie—Furnaces
3700 W. Gossage—Treating gases evolved during copper smelting
3701 R. W. Pyne—Manumotive and pedomotive carriages

DATED DECEMBER 22nd, 1869.

3702 J. Loader and W. H. Child—Steam boilers
3703 J. Pritchard and J. Collins—Embroidering
3704 J. M. Gray—Steam engines
3705 J. Bourne—Production of heat
3706 J. Brooke—Blankets
3707 H. Bessemer—Steam vessels and preventing sea sickness
3708 E. Fuller, G. Spencer, and E. Martin—Feeding bottles
3709 J. Ashbury—Screw wrenches
3710 W. P. Williamson—Fastenings for trunks and boxes
3711 W., T., and J. Mckenzie—Sharpening mowing machine cutters

DATED DECEMBER 23rd, 1869.

3712 R. Turner—Spinning cotton
3713 E. Ibos—Boot soles
3714 J. Rae and J. Wright—Supplying inland towns with sea water
3715 B. Hunt—Railway sleepers
3716 J. Woodward—Bricks
3717 J. B. Gough—Studs
3718 C. H. Roeckner and W. H. Northcott—Disintegrating wood
3719 R. Spear—Governors for steam and other engines
3720 R. Spear—Pneumatic engines
3721 J. C. Walker—Stoves
3722 W. E. Newton—Adjusting and packing rails of railways
3723 W. E. Newton—Joints for the permanent way of railways
3724 H. E. Newton—Traction engines
3725 A. M. Clark—Curtains

DATED DECEMBER 24th, 1869.

3726 W. Sumner and E. H. Waldenstrom—Boring copper
3727 W. Sumner and E. H. Waldenstrom—Cylinders
3728 R. Thomas—Propelling ships without screw or paddles
3729 G. E. Baron—Cutting loaf sugar
3730 G. M. Molesworth—Rails employed with grip wheels for working traction engines
3731 J. Hargreaves and T. Robinson—Treatment of pyrites
3732 P. Currie—Drying woven fabrics
3733 W. H. Baxter—Measuring corn
3734 W. McAdam—Collecting fares on tramway cars
3735 T. G. McDiarmid—Rigging ships
3736 W. R. Lake—Metal tubing
3737 W. E. Newton—Heating water
3738 W. White—Velocipedes
3739 F. F. Benvenuti—Inkstand
3740 S. Dixon—Petticoats
3741 S. Walker and E. Holt—Pumping
3742 H. J. Girdlestone—Commodes
3743 C. Drake—Portable stove
3744 N. Grew—Measuring the weight of water supplied to boilers

DATED DECEMBER 27th, 1869.

3745 E. P. H. Vaughan—Fluoride of potassium and sodium
3746 T. H. Lloyd—Valves
3747 F. W. Webb—Crushing metals and other materials
3748 G. A. Marriott and E. Holt—Engines
3749 P. Pearce—Gearing
3750 W. Adams—Firearms

DATED DECEMBER 28th, 1869.

3751 L. Schalleidner—Stamping wax and other candles
3752 G. Spencer—Preserving animal and vegetable substances
3753 C. Gordon—Firearms
3754 W. R. Lake—Steam boilers
3755 G. W. Rawsou—Promoting the combustion of smoke
3756 A. Upward, J. Bannehr, and T. P. Dale—Purifying gas

DATED DECEMBER 29th, 1869.

3757 R. H. Kay and A. T. Richardson—Crape
3758 W. Sinnock and J. Polglase—Machinery for crushing ores
3759 P. Gledhill—Cutting coal
3760 T. Edwards—Steam engines
3761 B. G. Harrmann—Separating metals
3762 W. E. Newton—Tilting vessels
3763 W. Richards—Firearms
3764 H. N. Maynard—Piers

DATED DECEMBER 30th, 1869.

3765 W., J., M., and T. Helliwell—Construction of bobbins
3766 J. O. Butler, J. Nichols, and W. Heslop—Tyres
3767 W. F. Petersen—Lifeboats
3768 R. Derham—Washing potatoes
3769 W. R. Lake—Roasting iron pyrites
3770 J. Howard—Steam boilers
3771 J. R. Wigham—Gas burners for illuminating beacons
3772 G. T. Bousfield—Harness operating mechanism for power looms
3773 T. Whitby—Bedsteads
3774 J. Stanton—Gun lock
3775 J. H. Johnson—Cast iron
3776 J. H. Johnson—Steel

DATED DECEMBER 31st, 1869.

3777 W. H. Richardson—Stamping gloss or crystal measures
3778 A. Mattiesen—Covering telegraph conducting wires
3779 G. Hamilton—Steam boilers
3780 H. E. Newton—Electro magnetic engines
3781 A. Bradshaw—Printing machines
3782 T. F. France—Baths
3783 C. A. Calvert—Checking money
3784 A. Chaplin—Steam boilers
3785 F. J. Bolton—Fermented liquors
3786 J. Wright—Indicating the mileage of cabs and other vehicles

DATED JANUARY 1st, 1870.

1 C. Hodgson—Substitute for wire ropes
2 G. Goold—Spoons
3 S. Holman—Fastening lids
4 R. A. Mull—Tramways
5 J. Eice and R. Bond—Temples for looms
6 G. Richardson—Supplying baths and other places with hot water
7 H. Turner—Weaving
8 W. R. Lake—Harness
9 C. Drake—Construction of concrete buildings

DATED JANUARY 3rd, 1870.

10 W. E. Gedge—Human power locomotive, termed the Family Calash
11 F. J. Duggan—Stoves
12 H. H. Cochrane—Working signals and switches on railways
13 E. Knowles and G. Hartley—Looms
14 J. Smith—Wires connected with mules for spinning
15 T. C. Olney—Gas stove
16 W. R. Lake—Securing bales of cotton
17 W. E. Newton—Electro magnets
18 W. Cockburn—Horseshoes
19 W. Palmer—Lighting carriages
20 F. Foster—Measuring fluids
21 D. Forbes—Artificial manures
22 C. Wyndham—Apparatus connected with two wheeled velocipedes
23 H. B. Barlow—Manufacturing fishing and other nets

DATED JANUARY 4th, 1870.

24 T. and R. Nuttall—Counterpanes and similar articles
25 E. C. Marie—Buttons
26 T. Griffin—Securing trinkets on chains worn with jewellery
27 J. Gordon—Yarns
28 J. G. Tongue—Purification of syrups
29 W. H. Adcock—Construction of steam boilers and generators
30 E. Cottam—Shoes for horses and other hoofed animals
31 C. H. Lea—Apparatus for signalling trains in foggy weather
32 T. Bannehr—Propelling carriages
33 C. L. Thiery—Watch cases

DATED JANUARY 5th, 1870.

34 C. W. Siemens, E. A. Cowper, and C. Cochrane—Stoves
35 I. Baggs—Purifying gas
36 C. H. Westendorp and D. Dowling—Breech-loading firearms
37 W. S. Lowe—Sizing machines
38 E. Edwards—Valves
39 Y. Duxbury—Paper
40 R. Ruddle and T. Parker—Heating churches and other buildings
41 E. T. Truman—Cleaning gutta percha and like substances
42 L. C. W. Schutte—Sugar cane mills
43 H. Plummer—Sewing machines
44 W. Wharton—Spinning and manufacture of tobacco
45 A. N. C. Gavard—Cartridge case for breech loading firearms

DATED JANUARY 6th, 1870.

46 J. Hargreaves and T. Robinson—Treating pyrites, &c.
47 G. D. Kittoe and P. Brotherhood—Packing pipe and other joints
48 W. Weild—Winding yarn or threads on to bobbins
49 J. Michels—Fastening and unfastening the doors of carriages
50 G. Shand—Obtaining products for vegetable and mineral tars
51 J. J. Miller—Reversing marine and other large engines
52 P. Jensen—Fastening neckties, cuffs, and other articles
53 C. East—Boots
54 J. H. Johnson—Heating apparatus
55 A. A. Ibbotson—Securing the ends of railway rails

DATED JANUARY 7th, 1870.

56 W. J. Purcell—Speedily moistening the sheets of a letter book
57 H. Pritty—Damping paper
58 R. Morris and M. D. Penney—Treating animal waste
59 W. R. Lake—Mowing machines
60 J. Gamgee—Preserving animal substances
61 J. Carnaby—Dials for gas regulators
62 T. Coltman—Knitted fabrics
63 G. G. Tandy, J. A. Dryden, and W. Perkins—Combustible liquids for illuminating and other purposes
64 B. Brown—Spinning cotton

DATED JANUARY 8th, 1870.

65 G. Little—Combing wool
66 J. H. Robinson—Ships
67 W. H. Hughan—Treatment of sewage
68 H. W. Lowden—Ascertaining the consumption of liquids
69 A. M. Clark—Spring seats
70 W. Thomson—Bending metals
71 J. H. Bass—Teapots

DATED JANUARY 10th, 1870.

72 C. D. Abel—Production of castings from cast iron
73 W. G. Cunningham—Cleaning boots
74 W. W. Hughes—Furnaces
75 J. H. Johnson—Bleaching
76 H. M. Richardson—Lamps

DATED JANUARY 11th, 1870.

77 A. Cochran—Apparatus for discharging water from steam pipes
78 J. E. Lipscombe—Filters
79 E. Gaillet—Ploughing
80 E. A. Chameroy—Gauging or regulating the flow of water
81 J. H. Johnson—Puddling iron
82 O. Vivier—Indicating the distances travelled by vehicles
83 C. M. Wade—Railway switches
84 W. Capion—Sewing machines
85 R. D. Dwyer—Roofing buildings
86 R. D. Dwyer—Self closing tap for drawing off liquids
87 W. R. Lake—Sharpening knives

DATED JANUARY 12th, 1870.

88 H. T. Humphreys—Railroads with jaunting cars and boats
89 T. G. Hemery—Photography
90 B. J. B. Mills—Tramways
91 F. H. Keevitt—Blinds for windows, doors, and other apertures
92 H. Jones—Firearms
93 L. Sterne and J. G. Warner—Bolts for permanent way of railways
94 A. A. Hely and J. Marshall—Facilitating human locomotion
95 J. Ambler—Twisting cotton
96 W. Cenison and H. Teall—Marine and other engines
97 W. H. Bamain and W. J. Menzies—Storing vitriol
98 W. E. Newton—Sugar
99 W. Goreham and L. White—Manufacture of Portland cement

DATED JANUARY 13th, 1870.

100 G. Kent—Rotary knife cleaning and polishing cement
101 A. B. Ibbotson and J. A. Lindhlad—Railway chairs
102 A. Clark and A. V. Winkle—Bottling soda water
103 H. E. Newton—Billiard cushions
104 A. V. Newton—Preparing fibrous substances for spinning
105 A. V. Newton—Knitting machine
106 A. V. Newton—Spinning
107 J. Taylor—Combing wool
108 J. Greenshields—Obtaining oil from carbonaceous substances
109 J. Cross—Umbrella frames
110 W. F. Chapman—Cases for exhibiting cut flowers
111 E. Leigh—Permanent way of railway
112 J. Wright—Exhibiting names, &c.
113 G. Thorneloe—Regulating the flow of liquids in pipes
114 A. B. Ziesthaug and F. L. H. Schmidt—Firearms
115 J. Lusty—Sewing machines
116 T. Restell—Cartridges
117 W. Thornley and S. Spencer—Steam boiler and other furnaces

DATED JANUARY 14th, 1870.

118 J. Leetch—Communication between different parts of a railway
119 P. Nisser—Substitute for gunpowder
120 E. Cottam—Pipes for smoking
121 W. Sinton—Churns
122 H. A. Bonneville—Warming and ventilating carriages

DATED JANUARY 15th, 1870.

123 A. C. Jonais—Watches
124 J. Wadsworth—Steam boilers
125 M. Anderson—Preventing the downward draught in chimneys
126 W. F. Reynolds—Ships' logs
127 J. Watson—Feed motion of sewing machines
128 T. R. H. Fisken—Breaking flax
129 J. Robinson and J. Smith—Cutting wood
130 A. M. Clark—Wooden pavements
131 E. J. Jeffs—Recording the number of passengers who travel in omnibuses
132 E. G. Wrigley—Rag engines
133 F. G. Fleury—Forcing liquids
134 G. Lampen—Shots

DATED JANUARY 17th, 1870.

135 T. Welton—Bottle stoppers
136 T. Taylor—Prevention of smoke in steam and other furnaces
137 F. S. Lines—Ornamenting surfaces
138 G. Baker—Cutting splint
139 A. B. Rocke—Knobs for doors and similar fastenings
140 A. R. Gibbons—Ornamenting and embroidering fabrics
141 T. Peard, J. J. Castle, and I. Holmes—Securing latch handles
142 J. Richardson—Artificial manure

DATED JANUARY 18th, 1870.

143 T. B. Hubbell—Gas burner
144 W. Richards—Firearms
145 H. B. Barlow—Sizing yarns
146 H. B. Read—Travelling rug
147 H. Haines—Tin pipes
148 T. C. Sloggett—Preserving meat
149 H. W. Hammond—Continual lever
150 G. G. Bussey—Giving flight to the toy known as the Aiiel toy, and utilising the same for trap shooting
151 T. Whitehead—Combing wool
152 J. Mackenzie—Coupling carriages
153 J. H. Johnson—Treating tar
154 T. P. Balls—Compressing substances for artificial fuel

DATED JANUARY 19th, 1870.

155 W. H. Sleigh and J. Richardson—Sharpening tools
156 W. F. Padwick—Fire grates
157 E. T. Hughes—Preventing sea sickness
158 B. Clarkson and S. Charlton—Scale beam
159 E. T. Hughes—Looms
160 C. Gordon—Firearms
161 J. G. Tongue—Regulating the speed of prime movers
162 W. Mawe—Safes
163 J. Dewar—Manure
164 J. A. D. Cox—Paint
165 H. Ashworth—Spinning cotton and other fibrous substances
166 E. Wood—Steam boilers
167 J. C. Ramsden—Apparatus for producing piled surfaces
168 W. Mavitta—Sights for firearms
169 P. Currie—Hat hooks
170 D. Servante—Printing machinery
171 J. J. Richardson—Grinding pins used in cotton machines

DATED JANUARY 20th, 1869.

172 G. H. Gossip—Umbrellas
173 G. H. Ellis—Ladders
174 W. Noton—Carding engines
175 J. M. Kilner—Passage and control of cables and chains
167 G. Cochrane—Preparation of iron ores for smelting
177 G. E. Fowcus—Refining lead
178 C. A. Calvert—Checking money taken for admission to theatres, &c.
179 W. L. Wildy—Steam engines
180 D. Spill—Treatment of xyloidine
181 W. Simons and A. Brown—Dredging
182 W. R. Lake—Needles and needle arms for sewing machines

DATED JANUARY 21st, 1870.

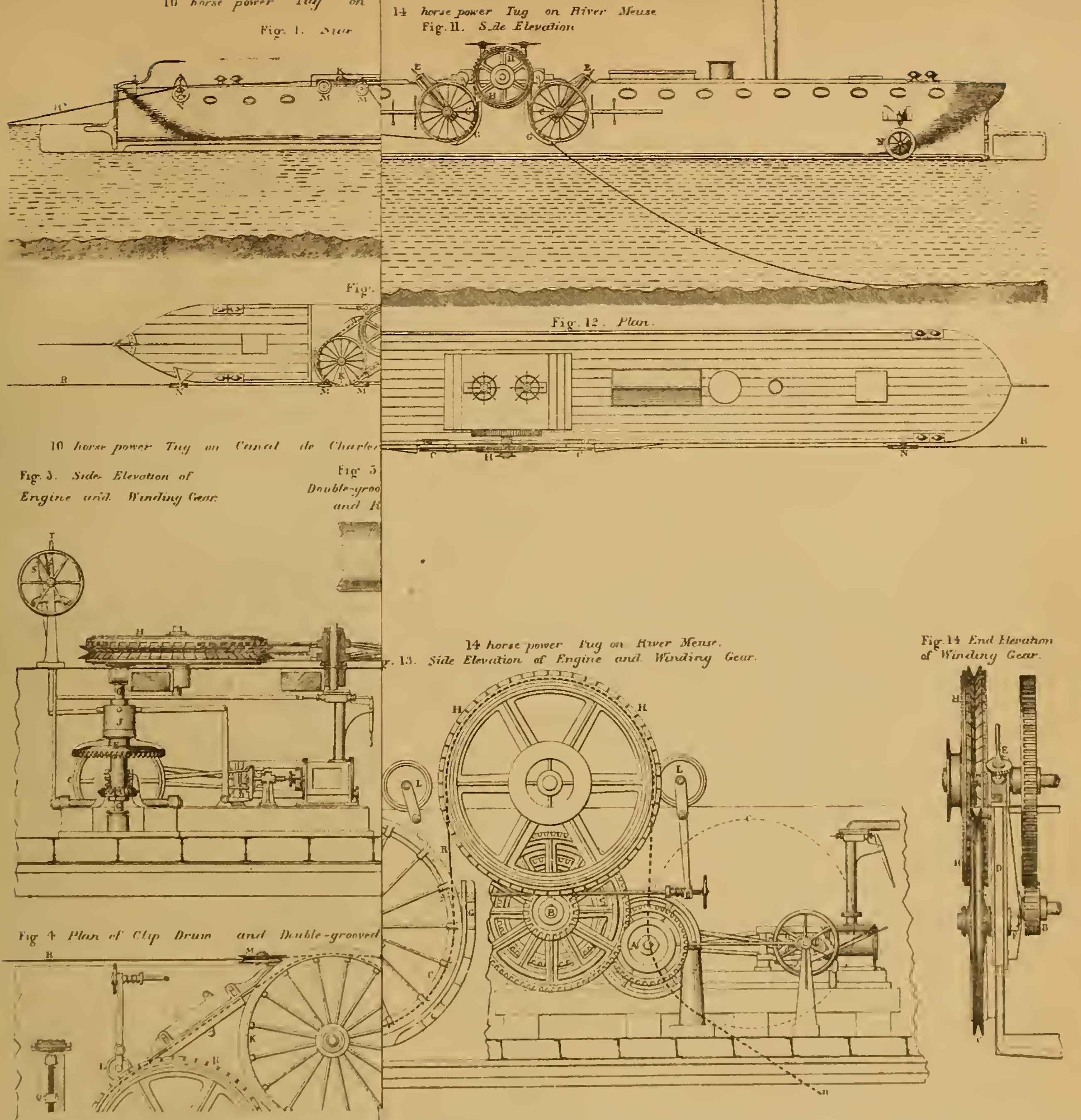
183 F. Rotig—Watches
184 W. E. Gedge—Preserving bread
185 M. Anderson—Discharging grain
186 J. Reichel—Buttons
187 F. Whitfield—Locks
188 T. J. Smith—Tinning wire
189 F. C. Southwell—Chaff cutters
190 W. E. Newton—Rendering substances applicable for use in journal boxes
191 F. Hockling—Fastening the leaves of books and music
192 W. R. Lake—Toy air gun
193 A. M. Clark—Chains

DATED JANUARY 22nd, 1870.

194 J. M. Plessner—Treating fuel
195 J. Macqueen—Self acting mules
196 J. Paton and P. and R. Harris—Carbonic acid gas
197 R. and T. Fielden—Pickers for looms
198 P. Sleigh—Strengthening cables
199 J. Dawson and T. C. Fawcett—Gigs used in raising the nap of cloth
200 W. H. Berry, G. Jowett, and J. Wood—Water meters
201 J. R. Johnson—Photographic paper
202 H. M. Whitehead—Preparing materials for making soap
203 W. T. Waite—Charcoal
204 W. T. Waite—Filtering
205 W. Garton—Preparation of fermentable saccharine matters
206 W. Dennis—Letter boxes
207 A. M. Clark—Electro motor for sewing machines
208 F. A. Barrow—Evaporating and concentrating liquids

WIRE-ROPE NAVIGATION

Plate 358



undoubtedly be a more effective mode of applying power than any method depending upon the resistance of the water as the fulcrum against which

* Read before the meeting, at Newcastle, of the Institution of Mechanical Engineers.

being thus exerted in an inclined direction, instead of nearly horizontally, the bow of the tug is depressed in the water; and the additional expenditure of power thereby occasioned becomes in deep water so considerable

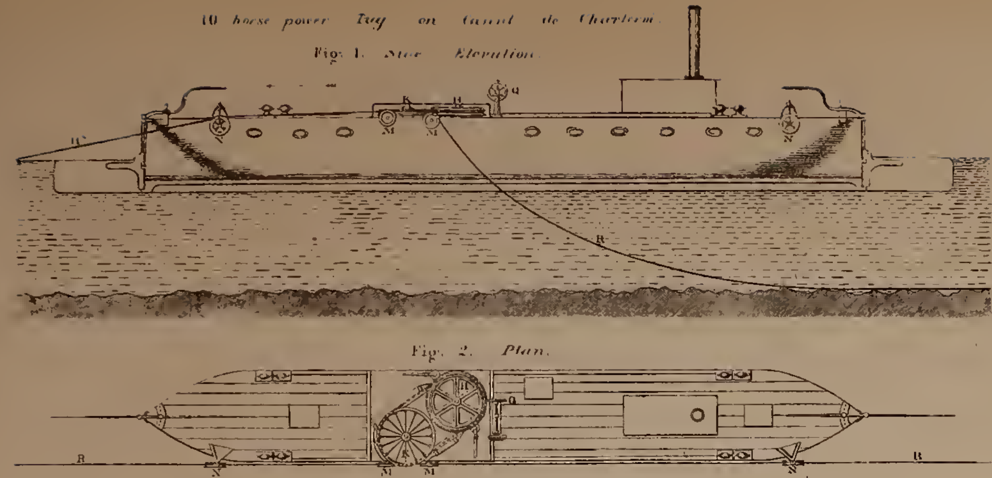
TOWING BOATS ON CANALS & RIVERS

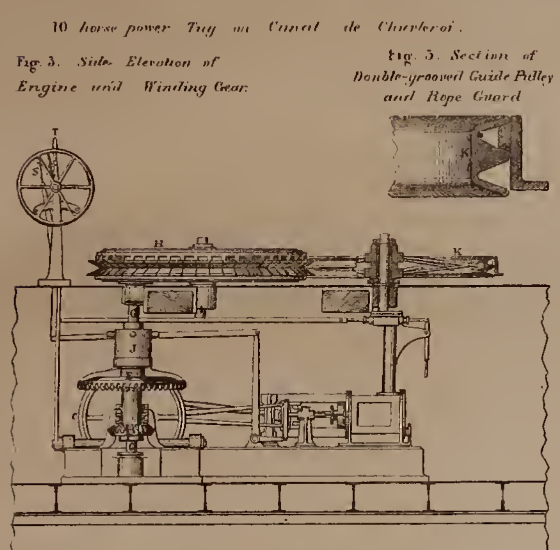
BY A

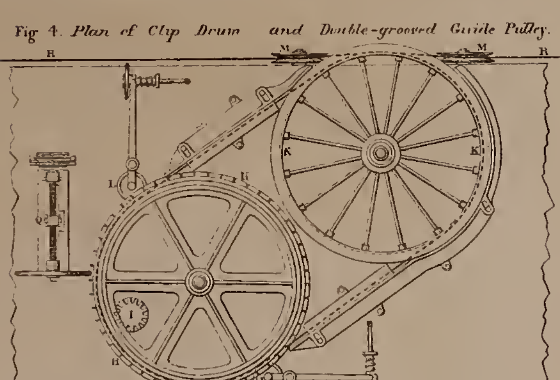
FIXED WIRE ROPE AND CLIP DRUM,

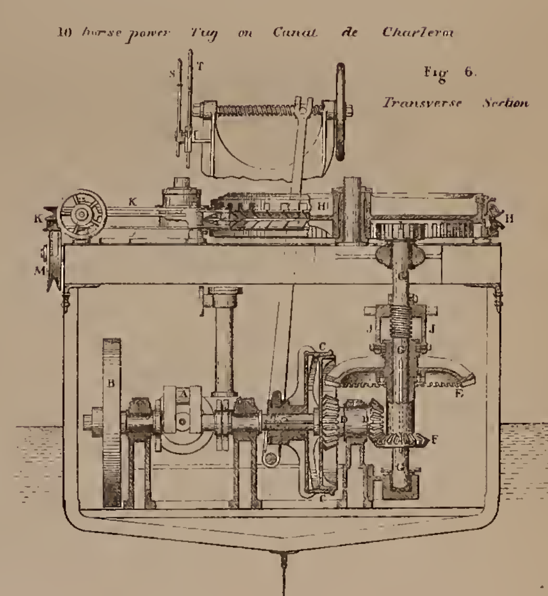
by

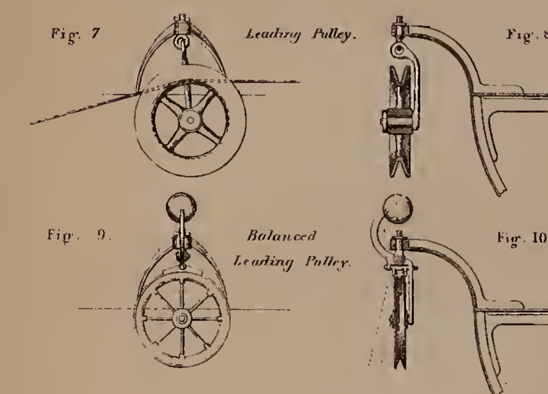
Mr MAX EYTH.

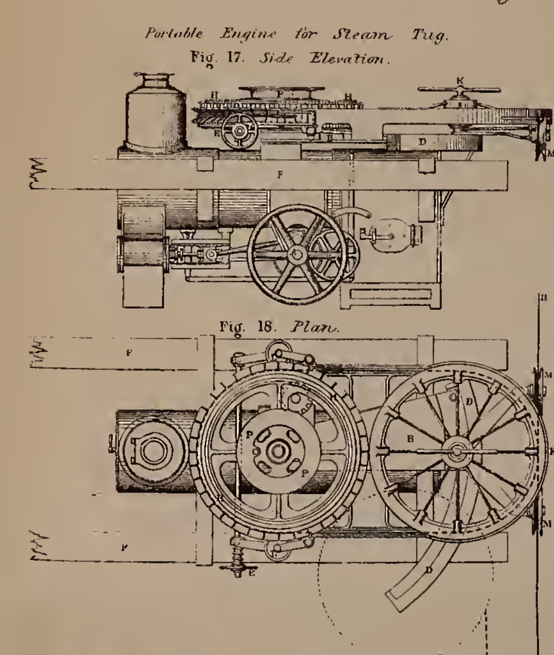


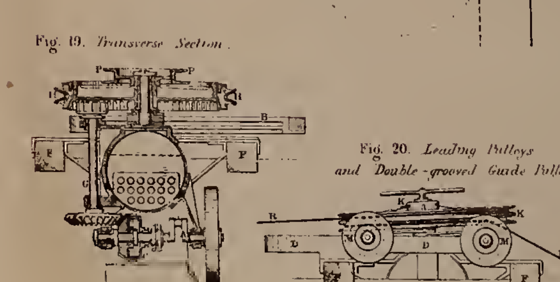


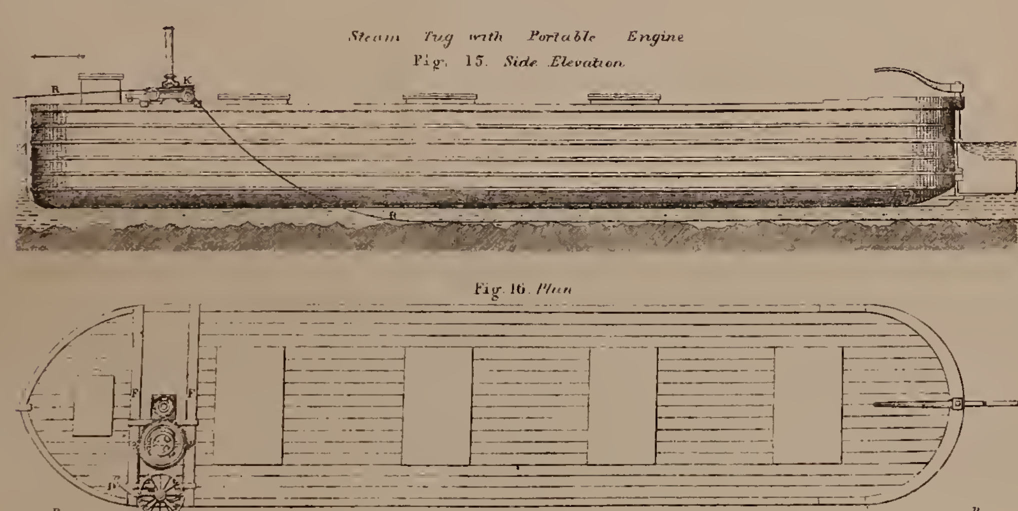


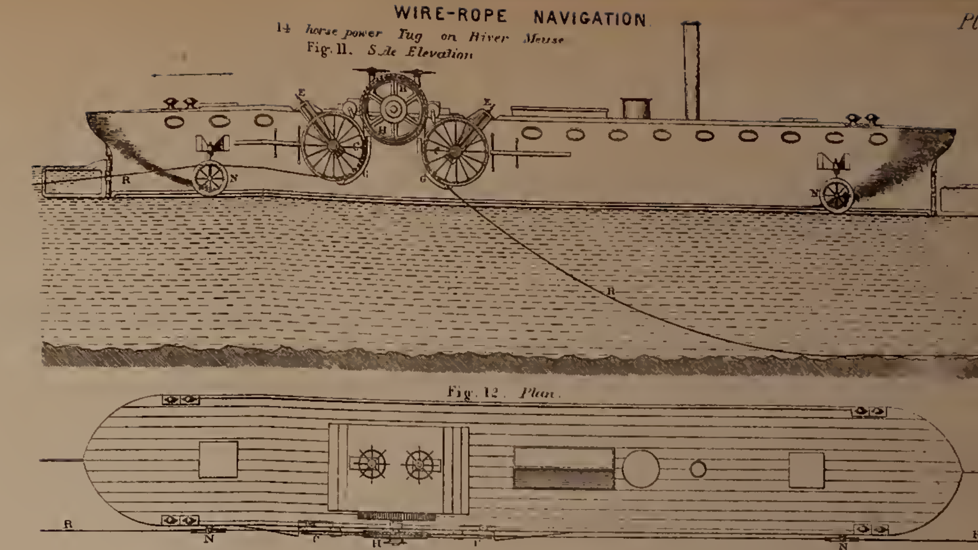


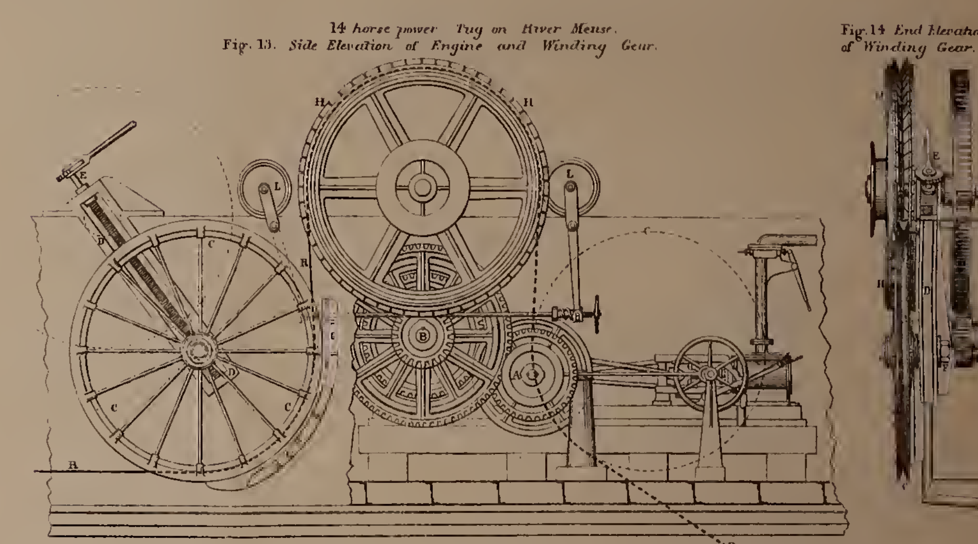


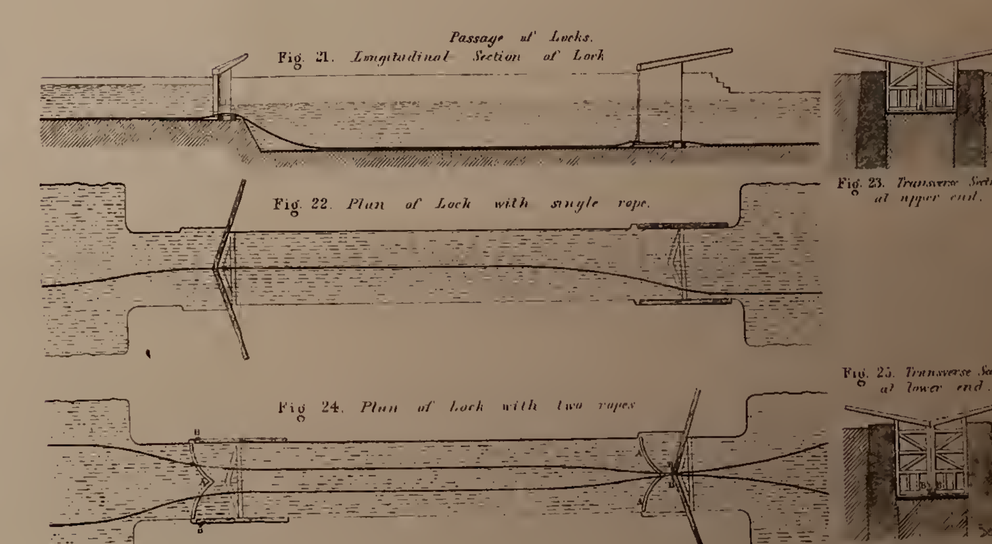












3754 W. R. Lake—Steam boilers
3755 G. W. Rawsou—Promoting the combuation of smoke
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DATED DECEMBER 29th, 1869.

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48 W. Weild—Winding yarn ar threads on to bobbins
49 J. Michels—Fastening and unfasteniug the doors of carriages ;

120 E. Cottam—Pipes for smoking
121 W. Sinton—Churns
122 H. A. Bonneville—Warming and ventilating carriages

DATED JANUARY 15th, 1870.

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[redacted]
207 A. M. Clark—Electro motor for sewing machines
208 F A. Barrow—Evaporating and concentratiog liquids

THE ARTIZAN.

No. 3.—Vol. IV.—Fourth Series.—Vol. XXVIII. From the Commencement.

1st. MARCH, 1870.

ON TOWING BOATS ON CANALS AND RIVERS BY A FIXED WIRE ROPE AND CLIP DRUM.

By Mr. Max Eyth, of Leeds.*

(*Illustrated by Plate* 358).

In the application of steam power to river and canal navigation the greatest obstacle to be encountered has been the loss of power that is inseparable from the ordinary methods of propulsion by paddle wheels or screw propeller. As the receding water here forms the fulcrum upon which the bearing is taken for propelling the vessel, the result is that a great quantity of water is put in motion, and a considerable amount of power exerted without any useful effect being produced. Thus, even under the most favourable circumstances, when working on a broad sheet of deep water, the ordinary propellers lose from 40 to 50 per cent. of the power applied to them; and under the peculiar circumstances met with on rivers and canals their useful effect is frequently reduced to less than 25 per cent. of the power applied.

On canals, the increased difficulties to be encountered arise from the presence of locks, the small section of water through which the boats have to be driven, and the swell produced by the increased speed of the boats, the small section of water not having been originally calculated for such a speed. Moreover, as the only admissible means of propulsion is by screws or paddle wheels placed at the stern, the water put in motion by them is withdrawn from the stern of the tug, and thrown against the bows of the boat in tow; the water level in the canal is thereby disturbed, and the hollow created at the stern of the tug has to be filled up by the water in front of the tug running backwards through the narrow passage left between the tug and the sides of the canal. The motion of the water being in the opposite direction to the advance of the tug, the skin-friction is greatly augmented, especially at the bottom of the vessel. The consequence is, that engines of considerable power have to be used for towing a given freight; and as the size and capacity of the boats in use on any canal are limited by the size of the locks through which they have to pass, it becomes of the utmost importance that the engines employed should occupy as little space as possible in the hold of the vessels, in order that the cost of steam propulsion may not be further increased by a serious diminution in the amount of freight that can be carried. Owing to the frequency of locks, which are generally constructed for the passage of only one boat at a time, the employment of larger tugs working a train of several barges is in most cases inadmissible, as each lock would stop the entire train during the whole time required for passing each barge separately through the lock.

On rivers, in addition to shallow places and small sections of the navigable channel, the principal impediments to steam navigation are the varying currents, by which the effect of the paddle-wheels or screw is reduced sometimes to a mere nominal amount. On the Rhine, for instance, it is a common occurrence for the large steam tugs of 500 effective horse-power, drawing three boats, to continue working full power against the currents near Bingen and St. Goar without making any advance. Ten or twelve horses are then attached to the tug, and are able without much difficulty to draw the whole train through the rapids of the river.

Under all the circumstances of navigation, and especially under those usually met with on rivers and canals, a dead pull from a fixed point must undoubtedly be a more effective mode of applying power than any method depending upon the resistance of the water as the fulcrum against which the propelling power is exerted; and this principle of a direct pull has accordingly been adopted as the basis of the system of navigation which forms the subject of the present paper, for towing boats on canals and rivers by means of a fixed wire rope and clip drum. The wire rope is laid in the bed of the canal or river from end to end, being anchored only at its two extremities; and an engine fixed upon the tug takes hold of the rope by means of a clip drum, round which the rope is passed. The clip drum being put in motion by the engine winds itself along the rope, lifting it up from the bottom of the canal in front of the tug, and dropping it again into the water behind. The engine thus exerts a direct pull upon the rope, which in consequence of its weight and the friction upon the bed of the canal does not materially alter its position. By this means the whole of the power applied to the clip drum is utilised in the propulsion of the boat, independent of the currents of the water or the section of the channel.

The idea of towing by means of a submerged rope or chain is by no means new, attempts in this direction having been made on the Rhine as early as the year 1732 by the French Maréchal de Saxe, for transporting war material through difficult parts of the river, by means of a horse windlass on the boat, winding up a rope made fast at the other end upon the river bank; on arriving at the end of the rope the boat was moored, while the rope was drawn out and secured again at a point higher up the river. In 1820 a regular service on this principle was established on the Rhone by Tourasse, and successfully overcame the very difficult parts of the river between Givers and Lyons; the tug boat carried an ordinary capstan driven by a steam engine, and was accompanied by two small auxiliary steamers acting as tenders to the tug, each containing a winding drum carrying a length of 1,100yds. of hemp rope 2in. in diameter. One of these tenders ran ahead, paying its rope out into the river and fixing it at the upper end to the mooring post; the tug boat meantime wound itself along the other rope previously laid, and the rope was delivered from the capstan of the tug boat to the winding drum in the second tug lying alongside, which afterwards ran ahead with it as soon as the end was reached. In this manner the tug worked its way along, using the two ropes alternately without great loss of time.

The employment of a chain in place of rope was twice attempted on the Saone between Lyons and St. Bernard; and in 1850 a steam tug working on a chain was started on the Seine, since which time two lines of chain navigation have been in active operation on that river, and still continue so, one extending thirty-two miles from Paris down to the mouth of the Oise, and the other rather a greater distance up to Montereau. The chains employed are of very great strength, being made of iron ¾ to 1in. diameter, in order to stand the violent shocks to which they are exposed by the passage of the tug boats. The tugs are 130ft. long by 23ft. beam, with 7ft. depth of hold and 16in. draft; and they carry engines of 60 horse-power working a pair of winding drums on parallel horizontal axes. The chain passing over leading pulleys at the bow and stern is led over the deck in a trough and supported by a number of carrying pulleys, and makes four or five turns round the pair of drums. The tug has a rudder at each end for running backwards or forwards, as it is not able to turn under the chain. The principal drawback in the working of these boats arises from the great weight of the chain, which has consequently a considerable inclination to the horizon in passing over the front leading pulley; the pull of the engine being thus exerted in an inclined direction, instead of nearly horizontally, the bow of the tug is depressed in the water; and the additional expenditure of power thereby occasioned becomes in deep water so considerable

* Read before the meeting, at Newcastle, of the Institution of Mechanical Engineers.

as to render the employment of a chain less advantageons than that of an ordinary propeller, the effect of the latter increasing with the depth of immersion.

Another difficulty in the use of a chain is the steering of the tug, as the great weight of the chain and its clinging to the river bed impede the lateral movement that is required of the tug, wherever the chain happens to lie out in the middle of the river. Where tho traffic goes principally in one direction, the chain gradually gets pulled tight against the inner bank of the cnrves in the river ; and in this case it is necessary to cut the chain, insert additional links, and draw it back into the middle of the river by manual labour, an operation which has frequently to be resorted to on the Seine. The jerks upon the links in the working of the chain tend to produce breakages, which generally happen in those parts of the river where the currents are strongest ; and the chain is also liable to break in passing over the winding drums, in consequence of one coil jumping on the top of another on the drums and thereby being driven at a greater velocity than the rest of the chain round the drnms. This occurs especially in going downstream at a considerable speed, at which time the chain is running rather slack on the drums. On the Elbe, where the same plan is also in use, fractures have been rare, in consequence of the unusual strength of the chains employed ; but the increased weight and cost of such chains are serious objections to their adoption. As it is impossible for two tugs working with winding drums to cross each other on the same chain, and as two chains are also impracticable owing to the liability of one overlying the other in the river bed, an attempt was made by Bouquié to employ pitched pulleys taking hold of the single links of the chain; but the unequal stretching of the links and the wear and tear of the pulleys caused the chain to slip and jump off the teeth of the pulleys.

The system of Wire-Rope Navigation, consisting in the employment of a clip-drum working along a submerged wire-rope, has been invented and matured by Baron Oscar de Mesnil and the writer of the present paper, the first experiments for the purpose having been made at Leeds in 1866, by Messrs. John Fowler and Co., under the direction of Baron de Mesnil, a Belgian gentleman, who has for many yoars devoted his attention to inland navigation. These experiments were afterwards repeated on a more extensive scale upon several American canals and also in Belgium, the results obtained being in every respect favourable ; and the system has consequently been ostablished upon a number of canals and rivers. The first application of this system was on the river Meuse, whero a line of wire rope of 42 miles length from Namur to Liège has been in successful operation from June, 1868, and is now about to be extended 90 miles through the Canal de la Campine to Antwerp. This will give a continuous line of 132 miles, partly canal and partly river, presenting examples of almost all the ordinary difficulties met in inland navigation. Wire ropes have also been laid on the Canal de Charleroi in Belgium, where a long and narrow tunnel offers great difficulties to the ordinary towing by horses ; and also on the maritime Canal de Beveland in Holland, between Rotterdam and Antwerp ; and on the Canal de Ternouze, which connects Ghent with the Scheld and is accessible for large sea-going vessels. Other lines are about to be established on tho Danube and the Rhine ; and for the latter a vessel is now building for the purpose of a series of experiments in the more difficult parts of the river.

In Figs. 1 and 2, Pl. 358, is shown the 10 horse-power tug employed on the Canal de Charleroi, in Belgium. The boat is 62ft. long, 8ft. broad, and 6ft. deep in the hold, drawing about 3ft. of water ; the hull is entirely of iron, the bow and stern being alike for running in either direction. There is a large rudder at each end, 8ft. long by 3ft. high ; and the keel is made unusually deep, projecting 1ft. below the flat bottom of the boat, as shown in the transverse section, Fig. 6. The large rudders and deep keel aro found of great service in the sharp curves of the canal, whore the tug is able to tow a train of from fifteen to eighteen barges of 70 tons burden each. The boiler is placed horizontally in the after part of the hull, and is of the ordinary locomotive construction having 200 square feet of heating surface and $6\frac{1}{4}$ square feet of grate surface. When working in the canal tunnel, the exhaust steam is condensed by being blown into the water of the canal, and the draught for the fire is produced by a small fan driven by the engine ; outside the tunnel the draught is produced in the ordinary way by the discharge of the exhaust steam.

The engine is shown to a larger scale in Figs. 3 and 6 (Pl. 358) ; it has a single 10in. cylinder, of 12in. stroke, fixed horizontally on a cast-iron bedplate in the bottom of the boat. The crank shaft A has a small fly-wheel B on one end, and on the other a friction clutch C, the loose half of which is cast in one piece with two bevil wheels D D, of nearly equal diameter, gearing with two bevil wheels E F, of different sizes, on a vertical shaft G ; a small pinion I, on the top of this shaft gears inside the rim of the horizontal clip-drum H on the deck of the tug. The two bevil wheels E F on the vertical shaft G, slide on feathers on the shaft, and are connected together by a long cast-iron neck ; and by means of a large nut, J, working on a screwed portion of the shaft, either of the two wheels is thrown into gear with the crank shaft, thus giving two different speeds for the clip drum.

The wire rope employed, R R, Fig. 4, is $\frac{5}{8}$in. diameter, and the clip drum H working upon it is 5ft. diameter, and turns loose on a centre stud fixed on a wood crossbeam flush with the deck, as shown in Fig. 3. A second stud carrics the double-grooved guide-pulley K, which is set slightly inclined, so that the rope passing off horizontally from the two sides of the clip drum enters the upper groove on one side of the guide pulley and the lower groove on the other side. Between the clip drum and guide pulley, and also in the grooves of the guide pulley, the rope is guarded by a slight cast-iron trough, or casing, lined with wood, as shown to a larger scale in the section, Fig. 5 ; the portions between the drum and pulley are cast in two halves to allow of readily opening whenover the rope requires to be taken out.

Two pressing pulleys L L, Fig. 4, held up by springs, press the rope into the clip drum, one of them only being generally in use at a time, for pressing the tail rope into the clips at the point where it quits the drum, according to the direction in which the tug is going. The rope is guided on and off the double-grooved pulley K by two small vertical pulloys M M overhanging the side of the tug ; and from the hinder of these pulleys the tail rope is usually allowed to fall direct into the water, as shown in Fig. 1. A leading pulley N, Fig. 1, swinging on a univorsal joint, as shown in Figs. 7 and 8, is suspended near each end of the tug, the pulley for the front rope only being in use at any one time.

A small winding drum P, Fig. 17, is provided on some of these tugs, turning loose on the centre of the clip drum, with which it can be connected by a pin, for the purpose of winding an auxiliary rope for towing barges through tho locks on the canal, while the tug is lying stationary alongside. The principal use of the winding drum, however, is to obtain a sufficient amount of slack in the wire rope for enabling the tug, when off the rope, to hitch on again at any place, without having to go to tho extreme end of the rope. For this purpose the wire-rope is picked up generally in the neighbourhood of a bend on the canal, where there is always some slack to be found, and is fixed securely to the bow of the tug ; the auxiliary rope from the winding drum being then fastened to the wire-rope near the stern of the tug, the wire-rope is by this means hauled in until a sufficient amount of slack is obtained for passing round the clip drum and the double-grooved guide-pulley.

The handles S and T for starting and reversing the ongine, and also the handwheel and screw Q for working the friction clutch C, are all on deck in convenient proximity to one another, Figs. 4 and 6. The friction clutch is essential with the single-cylinder engine employed on the tug, for bringing the load gradually upon it, as it would otherwise be impossible to overcome the inertia of a long train of barges, without the engine continually sticking fast on the centres. The usual speed of the engine is 80 revolutions per minute, with 90lbs. pressure of steam ; but the speed can at any time be increased without inconvenience to 100 or 120 revolutions per minuto. The gearing is so arrangod that at the ordinary speed of 80 rovolutions, the tug makes either one or three miles an hour. The very slow speed of one mile an hour is specially required in the tunnel, where the canal is so shallow and narrow that any greater speed wonld drive the water in front of the first boat of the train, so much as to canse the hinder ones to get aground.

This tug was put to work on the canal a few months ago, another f similar construction having been started experimentally abont a year ago the engines and machinery of both, as well as the rest of the machinery described in the present paper, were constructed at Leeds by Messrs. John Fowler, and Co.

In Figs. 11 and 12 is shown a 14 horse-power tug on the River Meuse. The boat is 80ft. long and 13ft. beam, with 7½ft. depth of hold, drawing 3ft. of water. As there are currents in the river, facilitating the steering, and a higher speed is admissible in this case, the keel and rudders are of smaller dimensions than in the canal tug previously described. The boiler has 200 square feet of heating surface, and 7½ sqnare feet of grate surface, and is of ordinary locomotive construction, fixed longitudinally in the boat. The engine is a horizontal double-cylinder one, fixed on a bedplate and wooden framework in the bottom of the boat, as shown to a larger scale in Fig. 13; the cylinders are 7⅝in. diameter by 12in. stroke. As three different speeds are required with the tug, an intermediate shaft B is introduced between the crank shaft A and the clip drum H, as shown in Fig. 14; and the spur wheels are thrown in and out of gear by ordinary clutches, a friction clutch not being required with double-cylinder engines.

The clip drum is 6ft. diameter, and is placed vertically, projecting over the side of the boat by the amount of its breadth, Fig. 14. The rope R is led on and off the drum by two 6ft. guide-pulleys, C C, Fig. 13, the bearings of which slide in long inclined slots D bolted on the side of the boat, and are raised or lowered by hand screws E; in their lowest position, in which they are fixed when towing, as shown in Fig. 13, each pulley is further secured by a locking nut F, Fig. 14, on the inside of the slot. The object of this arrangement is to afford greater facility for getting the wire-rope off the pulleys and throwing it overboard, when disconnecting the tug from the rope, for which purpose the locking nuts are slackened and the guide pulleys are drawn up the inclined slots by the hand screws into their highest position, as shown dotted on the left-hand side in Fig. 13, whereby the rope is completely slackened, and can be thrown off the clip drum and guide pulleys by hand with the greatest facility. The replacing of the rope is done in a similar manner, by putting it round the clip drum while the guide pulleys are in their highest position, and the latter are then screwed down upon the rope into their working position.

The pressing pulleys L for pressing the tail rope into the groove of the clip drum are worked by a flat spring, and are so arranged that while one of them is acting the other is off, one only being required at a time. The rope guards G are fixed cast-iron flanges bolted to the side of the boat and lined with wood. In screwing the guide pulleys upwards, the guards are left behind, and the rope can readily fall out of the grooves of the pulleys. The leading pulleys N, Fig. 11, at the two ends of the boat are similar to those previously described, and the universal joint by which each is suspended, has a counterbalance weight attached to it, as shown in Figs. 9 and 10, enabling the pulley to adjust itself with perfect facility to the slanting position required by the rope.

The engine makes 70 revolutions per minute, and the three corresponding speeds of the vessel are 1½, 3, and 6 miles an hour; the lowest speed is specially intended for working against the strong currents during the winter, while the quick speed is intended for the down traffic, and can be increased to 10 miles an hour by running the engine at 120 to 130 revolutions per minute. In three tugs subsequently built for this line, auxiliary screw propellers have been provided, for the purpose of going down stream with the propeller, so as to use the wire rope only for the traffic going up the river. One of these engines works a horizontal clip drum, which gives a very neat arrangement, leaving the deck and sides of the boat free and unencumbered; and the pressing pulleys being worked by weights instead of springs, allow of using a rope in which the joints are made with shackles instead of splicing.

In Figs. 15 and 16, is shown a canal tug worked by a portable engine of the smallest class used for the purpose; the engine is placed on an ordinary canal boat, and on arriving at the end of its journey can be taken off and placed on another returning boat. Usually the size of canal barges is so great that in passing locks and bridges nothing whatever can be allowed to project beyond the side of the vessel. Frequently also the bridges are so low that when the barge is empty very little space above deck is left for any parts of the machinery projecting in that direction. Also in regard to length, the locks do not allow any additional room; and to avoid diminishing the freight, as little space as possible should be taken from the hold of the barge. These conditions render the construction of suitable machinery for the ordinary canal service by no means an easy matter.

The portable engine now described, which is shown to a larger scale in Figs. 17 to 20, has a small tubular boiler, fired from the side of the firebox and provided with a steam dome through which the chimney passes. A single-cylinder engine of the ordinary portable-engine type, is fixed underneath the barre of the boiler; and the crank shaft A drives by a friction clutch C and a pair bevil wheels a vertical shaft G gearing with a horizontal clip drum H of 4ft. diameter, which is carried on a centre stud bolted on the top of the boiler.

The double-grooved guide-pulley K is centred upon a moveable platform B, which turns round the centre stud of the clip drum and works on a slotted circular arc D fixed upon the top of the boiler, as shown in the plan Fig. 18. This radial platform also carries the two rope guards, consisting of cast-iron troughs lined with wood; and also the two pressing pulleys L L, which are worked simultaneously by a handwheel E acting on a screwed rod and spiral spring. The two small vertical leading pulleys M guiding the rope R into the grooves of the double-grooved pulley K are carried upon two radial arms turning on the centre stud of the double-grooved pulley. The entire engine is suspended between two beams F placed across the deck of the tug near the bow, so that the boiler stands across the boat, and the double-grooved guide-pulley K in its working position projects 1ft. or more over the side of the vessel. Whenever the tug approaches a lock, a pin which fixes the radial platform B in its ordinary position is withdrawn, and the strain of the rope itself then pulls the platform round, as shown dotted in Fig. 18, drawing in the projecting portions of the apparatus within the edge of the deck, so that the tug can pass through the lock without any obstruction. After passing through, the engine is reversed for a few strokes, causing the radial platform B to be drawn out again by the rope into its original projecting position, in which it is then secured by the fixing pin.

The weight of the whole apparatus, which is capable of towing at 2½ miles an hour two barges of 200 tons burden each, does not exceed 2½ tons; and its length and breadth are respectively 10ft. and 4¾ft., the extreme height above deck being only 2½ft. and the depth below deck 3½ft.

The wire ropes employed on the several lines now in operation vary in diameter and material according to the circumstances for which they are intended. The smallest ropes in use are those on the Canal de la Campine and the Canal de Charleroi, which are ⅝in. diameter and made of charcoal iron wire; and the largest are those for the experiments now in progress on the Rhine, which are 1⅛in. diameter. On other lines ropes are used of ¾, ⅞, and 1in. diameter, some of them galvanised. The majority are simply charcoal iron wire ropes, but some are constructed partly of steel wire, and the rope used in the tunnel on the Canal de Charleroi is entirely of steel.

On ordinary canals, for barges of from 100 to 250 tons burden, and with the average number of locks which do not allow of trains being worked containing more than 2 or 3 barges, wire ropes ⅞in. diameter of charcoal iron are found to be quite sufficient, generally without galvanising. The breaking strain of such a rope is about 6¼ tons, and its weight 2lbs. per yard or 32 cwts. per mile; and the cost is from £48 to £53 per mile. When the traffic is an unusually heavy one, the employment of steel wire ropes is preferable. The breaking strain of a rope of the same diameter is thus doubled, and the cost nearly so; but the additional outlay is fully compensated by the increased amount of work that the steel rope will stand. The galvanising of the wires is in this case found to be entirely unnecessary, the experience of two years working having sufficiently demonstrated that the ropes are but little affected by oxidation, as they are constantly immersed several feet under water, and never exposed to the air long enough to become dry. On larger canals and especially on maritime canals, in cases where the speed is not considerable, but where large ships or long trains of vessels have to be towed, the wire-ropes should be ⅝ to ⅞in. diameter. An iron wire rope ⅞in. diameter weighs 2¼lbs. per yard or 2 tons per mile, and the cost per ton is slightly less than that of a ⅝in. rope, so that the cost per mile amounts to £60. The breaking strain of the ⅝in. rope is 8¾ tons, and of the ⅞in. rope 12½ tons. Steel ropes of smaller diameter in proportion to their increased breaking strain may be used with great advantage. For ropes laid in salt or brakish water it is indispensable that that the wires should be protected from oxidation either by galvanising or by a covering of tar and beeswax. The latter protection has the advantage of being easily renewed at any time without having to take the rope out of the canal; and it also obviates the injurious action that occurs of the zinc upon the iron when oxidation has once started in a galvanised wire rope.

On rivers, in consequence of the currents varying with the locality and the season, stronger ropes are required, of not less than 1in. diameter, having a breaking strain of 15 tons and weighing from 4½ to 5lbs. per yard or 3¾ tons per mile, their cost heing about £95 per mile. Where the required diameter of an iron wire-rope would exceed 1¼ or 1⅜in., it is advantageous to substitute a steel rope of equal strength, the cost of which will not much exceed, if at all, that of the iron wire rope. On lines of iron wire rope it will also be of great advantage to lay lengths of steel wire rope of the same diameter in the more difficult parts of the river, as in locks or in strong currents or very sharp bends, or where the bed of the river is particularly rocky, in order thereby to preserve a uniform degree of security throughout the whole length of the line of rope.

The laying of the wire ropes is a simple and inexpensive operation. They are generally supplied in lengths of a single mile each, coiled in the ordinary manner; the coil is placed on a vertical wooden windlass on the boat, and the rope is payed out over the stern, the boat being towed either up stream by horses, or better downstream by a small steam tug. A simple break is provided for tightening the rope as required during the paying out, the general practice being to lay it pretty tight along the straight portions of the line, and pay it out more slack in the bends. When the length of one mile has been payed out in this way, its end is spliced to the next coil; and five or six miles can be laid in a day without the slightest difficulty.

In the application of the power in the system of wire-rope navigation, the requisite hold upon the rope for the purpose of towing is obtained by means of the clip drum. As this ingenious contrivance, the invention of which is due to Mr. R. Burton, of Leeds, offers the only practical means at present known of taking hold of an endless rope with absolute security, its application has now become very general for steam ploughing, mining operations, and other purposes where large amounts of power have to be transmitted through considerable distances. Its application now described for the purpose of towing in navigation is the first instance in which the rope remains stationary while the clip drum travels along it.

As the effect produced by the series of clips gripping the rope round the circumference of the drum is simply equivalent to increasing the friction of the same rope round the circumference of a plain drum, a similar expression in each case gives the ratio between the strains on the leading rope and the tail rope, which increases with the extent of the arc of circumference or the number of clips that the rope passes over the drum. In order therefore to obtain any given amount of pull upon the leading rope, it is necessary that a proportionate degree of tension upon the tail rope should be constantly maintained; and as the tail rope in towing passes off slack from the drum, occasionally without any tension upon it, the required effect of tension upon the tail rope has in this case to be obtained by some other means; and this object is accordingly accomplished by the adoption of a pressing pulley, which acts in a direction radial to the drum, and is applied at the point where the tail rope leaves the drum, pressing the rope by a spring or weight into the grip of the last pair of clips on the drum, as shown at L L in Figs. 4, 13, and 18. The clip drum is thus the only contrivance at present in use by which a smooth rope can be firmly laid hold of, while leaving the tail rope completely slack, and at the same time without occasioning any injury to the shape or material of the rope by any excessive compression in grasping it; and the clip drum is therefore the principal mechanical feature in wire rope towing, without which the system would be impracticable.

The position of the clip drum, and of the guide pulleys guiding the rope on and off it, is either horizontal or vertical. In the horizonal arrangement with double-grooved guide-pulley, the leading rope generally lies in the upper grove of the guide-pulley, and the tail rope in the lower groove. In the vertical arrangement, the extent of circumference round which the rope passes on the clip drum is sometimes increased in the case of small engines to three quarters of a revolution, or nearly a whole turn round the drum, by employing only a single guide-pulley placed just below the drum; the leading rope then enters on the bottom of the drum nearly horizontally, and the tail rope passes off it over the guide-pulley at nearly the same place.

In the passage of the rope round the guide-pulleys, and especially in running between these and the clip drum, it has to be carefully guarded from jumping out of the grooves or getting entangled if at all slack. It has been found by experience that most careful attention has to be paid to this point; and the rope guards employed for the purpose consist of cast-iron troughs lined with wood, as shown in Figs. 4 and 13. The rope is in all cases led along the side of the tug, instead of over the deck in the centre line of the vessel, this arrangement being adopted on account of the great facility which it affords for getting rid of the slack rope behind the machinery. Where a very great towing power is required, it would no doubt be advisable for the rope to be central; and the greater stiffness of the larger rope then employed would of itself do away with the inconvenience which would occur on smaller tugs from the occasional slack of the tail rope. The leading pulley over which the rope passes at either end of the tug is about half the diameter of the guide-pulleys guiding the rope on the clip drum, as shown in Figs. 7 and 8; and the universal joint by which it is suspended is made simply by two wrought-iron rings, allowing the pulley to swing according to the direction which the rope assumes, and thus effectually preventing the rope from jumping out of the groove. Generally the front rope alone passes over the leading pulley, while the tail rope is allowed to fall direct into the water on leaving the guide pulley of the clip drum, although in so doing it occasionally rubs against the side of the tug.

The most important advantage attending the system of wire-rope navigation consists in the fact that nearly the whole of the power applied for the propulsion of the boat is here utilised. The trifling amount of loss may be illustrated by the case of the tug already described working on the river Meuse. In this instance the average depth of water is 12 feet, the weight of the rope 1·3 lbs. per foot, and the pull exerted at the clip drum 1¾ to 2 tons, or say 4000 lbs. The length of rope lifted off the ground ahead of the tug is therefore 270 feet; and its inclination at the leading pulley is such that the useful draft is reduced to 3984 lbs., being a reduction of only 16 lbs. on the original draft of 4000 lbs., or a loss of power of only 0·4 per cent. The mere lifting of the rope from the bed of the river does not occasion a loss of power, because the rope falls again to the same level behind the tug, so that one movement counterbalances the other, excepting only to the extent of the adhesion of the rope in the river bed. The vertical pressure upon the leading pulley by the weight of the unsupported length of 270 feet of rope amounts to 352 lbs., which increases the immersion of the tug to the extent of only 1-6th inch, so that the effect upon the motion of the tug is altogether inappreciable. The friction of the clip drum and pulleys, and the bending of the rope round them, can occasion only a very trifling loss of power, as there are only three bends altogether, and the pulleys and drum are all made of large diameter and move at a slow speed. Also the tendency of the tug to assume a slanting position in plan, in consequence of the draft being at one side instead of in the centre line of the boat, has only a nominal effect; for if the tug has a number of barges in tow, a slight inclination of the rudder keeps the tug perfectly straight. The only remaining loss of power is that which occurs in passing round the bends in the river or canal, where a displacement of the rope is occasioned by the passage of the tug; but when all these sources of loss of power are added together, there is no probability of the total loss amounting under any ordinary circumstances to more than 3 or 4 per cent. of the power applied to the clip drum, or say 6 or 7 per cent. of the power given out by the engine.

In working against a strong current or at a high speed, the useful effect obtained with the wire-rope system is slightly increased, owing to the rope in front of the tug being stretched into a more nearly horizontal position, so that the pull becomes still more direct; and, thus whilst the effect of paddle wheels or screw propellers is diminished in working against a current, the wire-rope tug works better, the greater the difficulties it has to overcome. The perfectly smooth and noiseless working of the rope round the clip drum and guide pulleys admits of almost any speed being attained that is compatible with the nature of the river or canal and the power available; and in this respect the wire rope has an advantage over a chain, which cannot be worked beyond a certain limit of speed, on account of the serious vibration and shocks produced in its passage over drums and pulleys.

The passage of the tugs through the locks is accomplished without any interruption in the continuous line of the rope. The mode of effecting this is shown in Figs. 21 to 23, which represent one of the locks on the river Meuse. At the bottom of the gates a small aperture is made for the passage of the rope through the joint of the gates when closed, by cutting a small piece out of each gate; and when the gates are open, the rope is perfectly free to be lifted and sunk again by the tug, which works its way in and out of the lock exactly as in the open river. The gates in closing sweep the rope back again towards the centre line of the lock, so that no attention whatever is required for replacing it in the centre.

Where the construction of the lock gates is such as to entail any risk of the rope jetting jammed underneath the bottom of the gate in closing, a couple of curved angle-irons bent to the circle described by the gates are fixed on the bottom of the lock, standing up a few inches above the sill, as shown at A A in Figs. 24 and 25; and each gate is provided at its bottom corner with a vertical iron bolt or finger B, which in closing sweeps along the flange of the angle iron, reaching an inch or two below its upper edge. By this means the rope, which always lies somewhere over the angle-iron, is swept towards the middle of the lock into the exact position of the opening, though which it passes in the closed gates.

One of the most important practical questions with regard to the working of the wire-rope system was whether the tugs would steer readily under all circumstances, but especially in sharp bends, where it was expected that a gradual if not a sudden shifting of the rope towards the inner side of the curve would inevitably be occasioned. On long straight lines the question was quickly settled most satisfactorily, as the great distance ahead at which the rope is lifted from the ground, and the slackness of the tail rope, allow the tug perfect liberty to move at an angle of more than 45° to the rope, within reasonable limits as to the extent of the lateral movement. The steering in curves is illustrated in the annexed diagrams, Figs. 26 to 29. On approaching a bend, as in Fig. 26, it is observed that at a considerable distance before entering the bend the engine suddenly makes several quick revolutions, as though running empty, in consequence of the rope at that moment being drawn out of the centre of the river towards the inner side of the curve. The slack thus gained being payed out behind the tug, as in Fig. 27, is temporarily deposited in the river bed at a place probably several hundred feet before the commencement of the bend. On entering the bend the tug is steered so as to keep off the inner bank; and the steering force acting at right angles to the rope, as in Fig. 28, produces a tension on the tail rope as well as the front rope, much greater in amount than that by which the rope was originally shifted. The slack previously deposited behind the tug is thus drawn forwards again into the bend of the river, the tug following the centre line of the river and laying the rope back again into its original central position, as in Fig 29. So completely is this effected that after a year's service on the river Meuse the rope is found in all the principal bends of the river to lie on the very outside of the navigable channel; and this result suggests a mode of restoring an even degree of tightness to the rope in places where on long straight lines it may have become stretched too tight, the original amount of slack being restored to the rope at those places by the simple expedient of steering the tug out of its straight course, making it travel in a zig-zag line between the two banks.

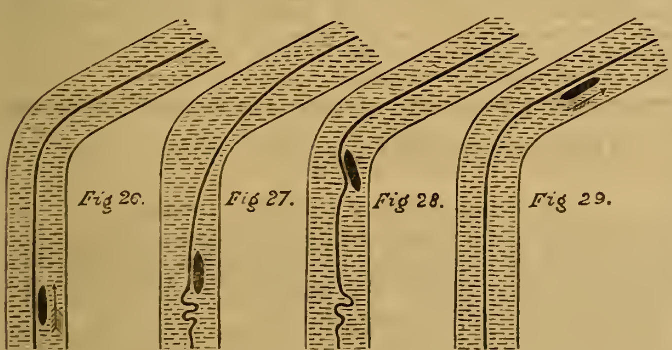


Fig 26. Fig 27. Fig 28. Fig 29.

With regard to the crossings of tugs working in contrary directions on a single rope, although the throwing overboard of the rope for this purpose by either of the tugs is greatly facilitated by the vertical arrangement of the clip drum, as shown in Figs. 11 to 14, yet on lines where there is much traffic the inconvenience and loss of time which cannot be entirely avoided in this operation render it advisable either to adopt some system of management whereby tugs shall not usually have to cross each other, or else to lay two ropes, one for the up traffic and the other for the down; and even a small amount of traffic is sufficient to repay the extra outlay for a second rope. Should the two ropes happen anywhere to overlie each other, and should the next tug passing be working along the under one, the smooth surface of the ropes offering no projections allows the top rope to slip freely off the under one, thus obviating the only objection that could be urged against the employment of a double line of rope. As an additional precaution a protecting fork is fixed on the tug in front of the leading pulley, to guard against risk of accident in any extreme case. If only a single rope be employed, the crossing of tugs may be avoided either by letting the two tugs exchange their trains of barges at the place where they meet, each tug then returning the way it came; or else by working each tug between two particular stations only; the latter plan however requires a very regular traffic, and cannot therefore be generally recommended.

With regard to the wear and tear of the wire ropes and their probable duration, the experience of two years' working has shown that they are not exposed to injury by oxidation, the water itself forming a secure protection to them in this respect. It is only in very shallow places, where also there is a very rapid current causing a little air to get mixed with the water and carried down to the bottom, that any spots of rust are found upon the ropes; but they are so slight in extent that even in these places the ropes may be expected to last thirty years without suffering any serious deterioration.

The effect of the mechanical action produced upon the wire ropes by bending and friction on the pulleys may be judged of from the facts obtained in other applications, were there is the experience of longer periods of working. In steam ploughing, for instance, a steel wire rope is bent some 40,000 times over a clip drum before requiring renewal; and in this case it is at the same time constantly running over small carrying pulleys and also rubbing along the ground. Similarly ropes in mines and on inclined planes are exposed not only to bending and friction over the machinery itself, but also to rubbing against surrounding objects in consequence of the ropes themselves being in motion. In towing however, the rope itself lies entirely at rest, and is only in use at the moment of the tug passing, at which time it is lifted from the bottom by the leading pulley of the tug and bent round three pulleys of large diameter. From these considerations, combined with the present condition of the ropes already in use for towing, there is reason for anticipating that good wire ropes made of charcoal iron not galvanised, working under the circumstances of any ordinary river or canal navigation, may be relied upon to last for at least ten years; so that the first cost of the rope and its subsequent deterioration become comparatively unimportant. In maritime canals, it is indispensable that the wire-ropes should be protected by galvanising, or by some other less injurious mode of preserving them. In a rapid river having a bed of small loose stones, as in the case of the Rhine, only ropes of hard steel and composed of wires of considerable diameter should be employed.

Any risk of the rope becoming silted up in the river bed could only be occasioned by heavy floods after a long severe winter; and where a river is locked up for several months during the winter, the rope should be drawn on shore for the time, and put in place again when the navigation is reopened. Accidental obstructions occasionally met with in the river beds arise from lost anchors, sunk trees, or large loose pieces of stone, getting caught and brought up by the rope. This frequently happens on first starting a new line; but after a month or two the channel becomes cleared by the rope itself, and accidents from this cause are exceedingly rare, and have never resulted in any serious breakage, although on the river Meuse the rope has brought up a dozen anchors, and on one occasion an entire cart.

No fractures of any of the ropes have occurred up to the present time; and the pull upon the rope so long as it is not exposed to sudden jerks may with perfect safety be carried up to one-third or even half of its breaking strain. Any bad places in the rope affect single wires only, so that in the same section there are still a number of good wires strong enough to stand the ordinary pull. In the event of a break the splicing of the rope would be the work of an hour only, and the splice if properly made is actually stronger than the other parts of the rope, the central hemp core being replaced at the splice by a strand of iron wire. When the pressing pulleys of the clip drum on the tug are held up by weights instead of by springs, the rope may be provided with ordinary steel shackles, and laid in lengths of only a quarter or half a mile each, which will in many cases prove to be an advantage fully compensating for the slight additional outlay required for the purpose.

On the line of wire rope in the river Meuse, extending over the 42 miles distance between Namur and Liége, there are eleven locks regulating the depth of water and the currents in the river; and the depth now admits any boats drawing less than 7ft. of water, up to 300 to 400 tons burden. The velocity of current averages only 2 to 3 miles an hour in summer, but in winter and spring it amounts sometimes to from 8 to 10 miles in the more difficult parts of the line, The river bed is very uneven, the depth of water varying from 8 to 25ft., and the bottom consists of mud, gravel, sand, and rocks, in different places; and in the upper part of the river there are some very sharp bends in its course. The rope in use is 1in. diameter, made of iron wire and the greater part galvanised; its breaking strain is 14 tons, the weight 4½lbs. per yard, and the cost, including laying down in the river, £93 per mile. There are four tugs in operation, of 14 to 20 nominal horse power, which generally work at about 4 miles an hour against the current of 2 or 3 miles an hour.

The maximum work done by the 14 horse-power tug first placed on the river consisted in towing 18 boats partly freighted, containing a total cargo of 1,000 tons; and in another instance the same tug towed 1,500 tons of freight in 10 boats. Both trips were made going up stream at the usual rate of 2½ to 3 miles and hour including stoppages. The average work of the tug is the towing of 700 to 900 tons in 8 to 12 boats of different sizes. Owing to the unavoidable delays at the locks the mileage per day is at present small, averaging only 20 to 22 miles in 10 hours; but in consequence of the successful working of the line it has been decided to increase the length of the locks, so that the whole train of barges may be worked through with only one opening of the lock-gates. As soon as this is done, the mileage will easily be raised to 30 or 40 miles per day.

The average consumption of coal by the 14 horse-power tug amounts to ½ ton per day, or about ¾ cwt. per mile, when working a full train to 8 to 10 boats; and the working expenses have averaged during the year about £22 per month. No accidents whatever have occurred, and the service has been maintained throughout the past winter, even during the time when in consequence of the high water the ordinary navigation was entirely stopped, and the passenger steamers between Liège and Seraing had to cease running. The three new tugs on this line are provided with screws for working down the river without using the rope, as there is very little work to be done in coming down stream. The adoption of the wire-rope navigation has already considerably augmented the traffic on the river, and will no doubt prove still further advantageous when extended to Antwerp in one direction and towards France in the other.

Another important practical illustration of the system is afforded by the case of the level on the Canal de Charleroi. This level is 6¾ miles long, including a tunnel of 1,400 yards or more than ¾ mile length; and the section of water in the tunnel being only a few inches larger than that of the loaded canal boats, the horses previously employed were 2½ hours in towing the boats through. At the present time one of the wire-rope tugs of 8 horse-power and another of 10 horse-power are employed, each of which takes a train of from 8 to 10 boats, each of 70 tons burden, through the tunnel in 50 minutes. On the rest of the canal as many as 20 boats are towed in a single train, notwithstanding the narrow and very crooked nature of the channel. Some of the bends have a radius of not more than 150 yards, and notwithstanding the slow speed that is rendered necessary by the small section of the canal and the bad state of the banks, the tugs steer round the bends with trains of boats in tow having an aggregate displacement fifty times as great as that of the tug itself. The tugs now in use take the place of thirty horses and thirty drivers, and do the work of fifty.

In America the experiments made in wire-rope towing have had reference exclusively to ordinary canal navigation. On most of the Pennsylvania and New York canals, which form by far the most important high roads for the inland traffic of those states, the average distance between the locks is only one mile, and their capacity does not allow of the passage of more than one boat at a time. Under these circumstances the employment of a separate tug or the formation of a train of more than two boats is quite out of the question; and therefore either an engine must be fixed in each separate canal boat, or else portable engines must be used, which at the end of each trip can be shifted on board returning boats, so as to avoid the machinery having to stand idle during the time that the boats are loading and unloading. A 4 horse-power portable engine, similar to that already described, has been working on the Hudson and Delaware Canal at Homsdale, where the channel is very narrow and crooked, and has towed two ordinary canal boats, freighted with 130 tons of coal each, at the rate of 2½ miles an hour, rounding the very sharp bends with perfect ease. This speed is double that attained at present by horse towing; and on the wider and straighter Erie Canal the same engine has towed two 200 ton loaded boats at the speed of 2¾ miles an hour, with a consumption of 40lbs. of coal per hour. The total space occupied by the engine, exclusive of the boiler, is 8ft. length by 4ft. width and 4ft. height, and its weight is altogether 2¼ tons; it has a single cylinder 5in. diameter by 10in. stroke.

The cost of towing by means of the wire rope and clip drum has been found from the experience of working on the lines at present in existence to amount to not more than 0·05d. ($\frac{1}{20}$th of a penny) per ton per mile, including the whole of the working expenses and management, interest, and redemption of capital. This result is not only another illustration of the great advantage which inland navigation possesses over any other mode of carrying a heavy traffic, where speed is not required; but it also proves the important commercial value of this particular mode of towing as compared with any other methods hitherto in general use. For the average cost of towing by animal power on four English canals—namely, the Gloucester and Berkeley, the Monkland, the Forth and Clyde, and the river Lee—amounts to 0·35d. per ton per mile; and on seven French canals the average is 0·27d. With paddle tugs employed on the Thames the cost of towing was 0·48d., whilst the average cost of towing by the same means on six rivers in France is as high as 0·80d. per ton per mile. The employment of screw tugs on three English canals—namely, the Gloucester and Berkeley, the Aire and Calder, and the Regent's canal—resulted in an average cost of 0·27d.; whilst towing by boats carrying their own machinery cost on seven English canals 0·20d. per ton per mile.

The charge made for the wire-rope towing on the Meuse during the regular season is 0·10d. per ton per mile for the up traffic, and 0·07d. for the down traffic. In winter, owing to the increased currents, it is raised according to the state of the water, the maximum charge being not more than 0·39d., or about the average cost of towing on level canals by other means of traction.

In conclusion it may be remarked that, while railways have undergone so wonderful a development during the past thirty-years, the quieter but often more important mode of transporting heavy goods by inland navigation has remained comparatively neglected. It is true that the natural features of this country are not very favourable for inland navigation, although there is in the United Kingdom a total length of 2,000 miles of navigable watercourses. But on the Continent, in the Colonies, and especially in India, there is a vast amount of traffic for which no better highways will be found than those already traced by nature in the rivers and streams penetrating the interior of the country.

The system of wire-rope towing that has now been described places inland navigation in a similar relative position to that in which the road traffic was placed by the introduction of the railway and the locomotive. By means of the clip drum the tug obtains a hold upon the flexible rope laid in the watercourse, precisely in the same manner as the driving wheel of the locomotive takes hold of the rigid rail upon which it runs; and the great advantages of steam power may therefore be similarly brought to bear on the movement of vessels in water, leaving to railways all their superiority in regard to speed, but restoring to rivers and canals their advantage in reduction of traction.

MANCHESTER STEAM USERS' ASSOCIATION.

CHIEF ENGINEER'S MONTHLY REPORT.

The last ordinary monthly meeting of the Executive Committee of this Association was held at the Offices, 41, Corporation-street, Manchester, on Tuesday, February 1st, 1870, Sir William Fairbairn, Bart., C.E., F.R.S., L.L.D., &c., President, in the chair, when Mr. L. E. Fletcher, Chief Engineer, presented his report, of which the following is an abstract:—

During the month of December 298 visits of inspection were made, and 679 boilers examined, 492 externally, 12 internally, 3 in the flues, and 172 entirely, while in addition 7 boilers were tested by hydraulic pressure. One of these hydraulic tests was an ordinary one, simply to ascertain the sufficiency of a boiler already in work, while in the other six cases, the boilers were new ones, and were tested by hydraulic pressure, as well as specially examined both as regards their construction and complement of fittings, before leaving the maker's yard. In these boilers 100 defects were discovered, 6 of them being dangerous. Furnaces out of shape, 3; fractures, 14,—1 dangerous; blistered plates, 11; internal corrosion, 19; external ditto, 17,—2 dangerous; internal grooving, 13; external ditto, 1,—dangerous; feed apparatus out of order, 2; water gauges ditto, 5,—1 dangerous; blow-out apparatus ditto, 3; safety-valves ditto, 2,—1 dangerous; pressure gauges ditto, 1; boilers without feed back pressure valves, 8; cases of deficiency of water, 1.

Explosions Prevented by Timely Inspection.

The mere inspection of a table stating that so many boilers have been examined, some of them "Externally" and others "Entirely," and also stating that so many defects have been met with, some from external corrosion, others from internal corrosion, &c., &c., awakens but little interest and gives but a faint idea of the value of the examinations, and the amount of human suffering and loss of property prevented. The two following cases, however, if given more in detail, may aid the realisation of this, and show the worth of timely inspection.

On examining two boilers of the ordinary Lancashire type, 7ft. in diameter, recently enrolled with this Association, it was found that they had only one safety-valve between them, this valve being placed upon the main steam pipe, and beyond the steam stop valves. This, it must be clear, is a most dangerous arrangement, as closing the stop valves would leave the boilers without any safety-valve at all, while it was quite possible this might occur to either one or both of the boilers through inadvertence. For instance, if one of the boilers were laid off for cleaning while the other was working, the stop valve on the idle boiler would have to be shut, in consequence of which, when the steam was being got up again, the idle boiler would be without any safety-valve at all. Under these circumstances the pressure gauge would be the only guide as to when the stop valve should be opened, and if this opening were deferred a little too long, with a brisk fire burning at the time, the results are not difficult to anticipate, to which it may be added that there was but one pressure gauge to the two boilers, while this was found to be taken off at the inspector's visit.

On examining the condition of the boilers, it was found that the plates on the top, which had been covered with flagging, were most seriously corroded, an eighth of an inch having been eaten away in some places, and three-sixteenths of an inch in others, while in one spot, the depth of the corrosion was as much as five-sixteenths, so that only one-sixteenth of an inch remained, and our inspector knocked a hole through. Added to this the boilers were found to be seriously attacked internally by corrosion. The rivet heads were considerably wasted, and several gone altogether, while a good deal of the overlaps was eaten away. The dangerous state of the top of the boilers had not been known till the flagging was lifted: but after examination, it was clear that the boilers were altogether too far gone to be repaired, and on a faithful report being made to the owners, they at once adopted the wisest course, not of patching the old boilers, but of laying down new ones, and these have within the last few days been set to work. In doing this the owners took advantage of the experience accumulated by the Association with regard to the construction, equipment, and setting of those boilers under its inspection found to give the best results, and they appear well satisfied with the course adopted.

With such an arrangement of safety-valve, it is a perfect miracle how the boilers escaped explosion, and as this case was met with within two or three miles from the Manchester Exchange, it shows that even in this manufacturing centre independent boiler inspection is highly necessary.

In the second case that may be referred to, a new member, residing about 300 miles from Manchester, recently enrolled a couple of Cornish boilers 6ft. 6in. in diameter. On the Association's Inspector examining these boilers for the first time, he found them both to be corroded externally all the way along the bottom where resting on the midfeather wall, which was 10 inches wide, the plates at one part being so wasted that a thickness of not more than one-sixteenth of an inch remained. The weakness in this case was apparent inside the boiler, and the Inspector, on sounding the plates sent his hammer through them. The owners at once had the boilers taken out, turned bottom upwards, and thoroughly repaired, though it would have been better policy to have laid down new ones instead. Two new boilers, however, could not be had at a moment's notice in the locality in question. Stopping the boilers involved stopping the works, the inconveniences and loss of which could have been saved by earlier inspection.

Explosions.

Seven explosions occurred during the month of December, by which fifteen persons were killed and four others injured. Not one of these explosions arose from boilers under the charge of this Association. The most important, viz., No. 49, is reported on below in detail. The others do not call for special notice, but particulars are given in a more abridged form in the tabular synopsis of the steam boiler explosions which occurred during the year 1869, which accompanies this report.

In addition to the above, a kitchen boiler exploded, killing one person and injuring another, and as these explosions recur so frequently at this season of the year when the weather is frosty, and often with fatal results, they are worthy of attention. I had quite hoped to have reported on this explosion, as well as on another of a similar character which happened a few months since, but the length to which I find this report just as it is going to press has attained, compels me to defer this till another opportunity. It may also be mentioned that a tar boiler explosion occurred during the month of December, killing one man and injuring another, while a similar one happened a few months before, killing four men and injuring one other. The explosion of tar boilers, therefore, is a matter of importance. I have obtained full particulars, but must defer further reference to these explosions, as well as those of the kitchen boilers, to a future occasion. The following is a tabular statement of explosions which occurred during the month under consideration:—

Tabular Statement of Explosions,

From November 27th, 1869, to December 31st, 1869, inclusive.

Progressive Number for 1869.	Date.	General Description of Boiler.	Persons Killed.	Persons Injured.	Total.
48	Dec. 1	Vertical Marine, Internally fired	3	0	3
49	Dec. 3	Vertical 'Furnace' Iron-works, Externally fired ...	8	1	9
50	Dec. 6	Single-flue, or Cornish, Internally-fired	0	0	0
51	Dec. 9	Locomotive, Internally fired	0	2	2
52	Dec. 11	Single-flue, or Cornish, Internally fired	0	0	0
53	Dec. 14	Single-flue, or Cornish, Internally fired	2	0	2
54	Dec. 29	Plain Cylindrical, Egg-ended Externally fired	2	1	3
		Total	15	4	19

No. 49 explosion was of a most distressing character, and suggests some important considerations with regard to the general responsibilities of boiler owners. This explosion occurred at about eleven o'clock on the morning of Friday, December 3rd, at an iron works, and resulted in the death of eight persons, as well as in injury to one other.

The boiler was of the externally-fired vertical "furnace" class, and heated by the flames passing off from three puddling fires, the flames impinging in the first instance on the bottom of the outer shell, and then ascending round it to about mid height, when they passed through openings in the side to a central descending flue, and thence to the chimney. The size of this boiler was considerable, at least so far as its diameter was concerned, the diameter of the shell being as much as 10ft. by 18ft. 6in. in height, and that of the central descending flue tube being 4ft. 2in. by 10ft., while the original thickness of metal appears to have been from three-eighths to seven-sixteenths of an inch, and the blowing-off pressure about 30lb. on the square inch.

The boiler gave way both in the central descending flue and in the external shell, the flue collapsing and the shell rending, in consequence of which, the whole was ultimately torn into some ten or eleven pieces, all of which were thrown to considerable distances, one as much as 75 yards, another 130, a third 150, and a fourth 200. These fragments, however, were not scattered in opposite directions as is so frequently the case, but were all thrown to one side only of their original position, while the boiler appears to have risen almost vertically from its seat like a rocket. This leads to the conclusion that the boiler failed in the furnace tube in the first instance, and that it was then shot upwards by the unbalanced pressure consequent on the issuing torrents of steam and water, the collapse of the tube starting the rents in the outer shell.

With regard to the cause of the collapse of the central descending flue tube from which the other rents sprung, it was found on examination after the explosion that the boiler had been seriously weakened by internal corrosion. The greater portion of some of the angle irons had been wasted away, and some of the rivet heads eaten off altogether, while the plating in the descending flue was reduced in places to a thickness of three-sixteenths of an inch, when it gave way under the ordinary working pressure of steam, simply from loss of material. This corrosion, however, was not confined to the central flue tube, but had attacked the external casing as well, reducing some of the plates to the thickness of about a quarter of an inch. Added to this, the boiler had to withstand the trying influence of external firing, and during the sixteen months it had been in use at the ironworks at which it exploded, it had been repaired some four or five times, in consequence of leakage, caused by the impingement of the flames from the puddling furnaces, a defect to which these boilers are always subject, which makes them extremely unreliable and dangerous. Thus the boiler was weakened both inside and outside, so that this explosion was clearly due simply to the condition of the boiler, which was so defective as to render it totally unfit for work.

The defects in this boiler were so glaring that they could not have escaped attention had the boiler been examined by a competent inspector.

This explosion underwent a very lengthened investigation by the coroner and his jury, and some points brought out in the evidence are worthy of notice. It appears that the boiler was purchased second hand about sixteen months before the explosion, having been repaired as well as worked elsewhere. On its repurchase it was again repaired, but it did not work long before it had to be patched again, and this patching seems to have been repeated some five or six times during the sixteen months the boiler was in use at the iron works at which it exploded. These constant repairs were rendered necessary by the mode in which it was heated, the impingement of the flames passing off from the iron furnaces springing the seams and making them leak, when the rivets had to be renewed and the plates recaulked. The engine-driver, who was in the habit of cleaning out the boiler, stated that "he never anticipated any danger, and always thought the boiler safe." A second engine-driver, who appears to have had charge of the boiler conjointly with the previous one, said "it was a safe and proper boiler to work so far as he could tell by looking at it when he cleaned it out, and he could give no reason for the explosion. It was true that the boiler was an old one, but he had seen new boilers explode." The master boilermaker who was entrusted with the repairs of the boiler when first purchased and whose firm had carried out the repairs since then, did not attribute the explosion to the defective condition of the boiler, but thought there must have been extreme pressure. Thus no satisfactory information was obtained as long as the inquiry was confined to interested persons; but fortunately other evidence of an independent and competent character was given. A scientific witness, experienced in boiler inspection pointed out clearly that the explosion was simply due to the defective condition of the boiler, which could not but have been detected on competent examination, while this view was corroborated by another engineer.

The jury gave the matter a great deal of careful consideration, and from the published reports the verdict appears to have been to the following effect:—"Accidental death from the explosion of an old and much worn steam boiler," the jury expressing their regret that more complete and competent examinations had not been made, as they considered that the boiler was too worn for the work it had to do, and that proper examination would have detected this. At the same time they did not consider that the owners were aware of the defective condition of the boiler, while they constantly exposed themselves to the danger arising from it. Had it appeared, however, in evidence that notice had been given of the dangerous state of the boiler, they should have felt it their duty to have brought in a criminal verdict. The jury concluded by expressing the hope that such boilers would shortly be under Government inspection.

This verdict gives much more practical information with regard to the cause of the explosion than is the case with the majority of verdicts, and, so far, is a great improvement upon them, while the jury evidently bestowed upon the matter a good deal of care and attention. While, however, the clear statement given at the commencement of the verdict with regard to the cause of the explosion is calculated to prove a serviceable warning to steam users, it is thought that the principle laid down at the latter part of the verdict is open to question, and indeed is fraught with the most serious consequences. In the early part of the verdict it is plainly stated that the boiler burst because it was an bad one, but in the latter part the owner is exonerated from the results of working this boiler on till it killed eight people because he had not taken the trouble to make himself acquainted with the condition in which it was. This is to offer a premium to ignorance, while the association is labouring to prevent explosions by the promotion of practical knowledge. The association holds that no man has a right to lay down a steam boiler for his own purposes,—a steam boiler being a most certain engine of death if neglected,—without ascertaining as far as lies in his power that it is absolutely safe, otherwise he imperils the lives of his workpeople, and should be held responsible for so doing. Were this view generally acted upon, explosions would shortly be at an end, but as long as a man may work a boiler for his own profit, and allow it to explode at the cost of the lives of his workmen, explosions will continue to recur as at present. No man has a right to let his boiler explode, and unless this principle is voluntarily accepted by steam users, public opinion will compel the Government to step in and interfere. The only way to prevent this is to render Government interference unnecessary by generally adopting a system of voluntary periodical inspection, which this association has already done so much to promote, and is willing yet further to extend.

Return of the Number of Steam Boiler Explosions from the Year 1863 to 1869, inclusive, with the Number of Persons Killed and Injured thereby.

Year.	No. of Explosions.	Persons Killed.	Persons Injured.	Total.
1863	48	76	80	156
1864	32	64	90	154
1865	48	46	79	125
1866	72	87	109	196
1867	36	60	67	127
1868	45	57	60	117
1869	58	86	126	212
Total for 7 Years	339	476	611	1087
Average for each Year	48	68	87	155

From the above table it will be seen that the number of explosions during 1869 was above the average, and supports the estimate given on previous occasions, that, as a rule, one steam boiler explodes every week, or in round numbers 50 explode every year, killing 75 persons.

For further convenience in reference the fifty eight explosions recorded in the year 1869 have been arranged under three heads. One, the service in which the boilers were engaged; another, the general class or construction of the boiler in each case; and the third, the causes from which the explosions sprung. These are given in the following tables:—

Table No. 1, showing the Service in which the Boilers were engaged from which Explosions arose in the year 1869.

Description of Service.	Number of Explosions.	Persons Killed.	Persons Injured.
Collieries	16	20	21
Tin and other mines	10	2	2
Ironworks..	5	15	11
Steamboats and steam tugs	4	17	10
Paper Mills	3	2	6
Agricultural..	2	2	5
Locomotive	2	0	2
Iron founders and nailcutters	2	2	4
Bobbin Turnery	1	15	33
Steam crane...	1	4	3
Cotton mill	1	1	2
Woollen mill	1	0	4
Miscellaneous:—1 rice mill; 1 saw mill; 1 bleach works; 1 brick works; 1 chemical works; 1 oil works; 1 shipbuilding works; 1 tin works; 1 wire works; 1 gun implement manufactory	10	6	23
Total..	58	86	126

On a consultation of the above table it will be seen that more explosions occurred, as in previous years, at collieries, mines, and ironworks, than at any other works, while those at ironworks were of a much more fatal character than those either at mines or collieries. Numerous as cotton and woollen mills are, only one explosion occurred at a cotton mill, and one at a woollen mill.

The following table shows the class of boiler from which explosions arose in the year 1869:—

Table No. 2, showing the Different Classes of Boiler from which Explosions arose in the Year 1869.

Description of Boiler.	Number of Explosions.	Persons Killed.	Persons Injured.
Plain Cylindrical, Egg-ended, Camber-ended, and Flat-ended ....Externally fired.	21	20	38
Single-flued or Cornish ......Internally fired.	14	12	15
Double-flued or Lancashire Internally fired.	4	17	38
Multitubular Marine Type Internally fired.	4	17	10
Double Furnace 'Breeches,' and Double Furnace Patent Conical Water Tube. Internally fired.	3	3	3
Portable, Vertical and Locomotive Type..................Internally fired.	3	5	8
Railway Locomotive. Multitubular ....Internally fired.	2	0	2
Furnace Boilers, Heated by Flames passing off from Iron Furnaces:—			
One Horizontal Double-Flued.....................Internally fired.	1	2	6
One Vertical ....Externally fired.	1	8	1
Wagon..............................Externally fired.	1	0	2
Rag Boiler ....No Fire, Heated by Steam.	1	1	2
Particulars not Precisely Ascertained......	3	1	1
Total.............................	58	86	126

On a consultation of the above table it will be seen that more explosions arose from, and more persons were killed by, the plain cylindrical, externally fired class of boiler, than any other. The introduction of the internally fired Lancashire boiler in the place of the plain cylindrical, externally fired, would certainly be productive of safety, and it is thought of economy.

The following table shows the causes from which explosions arose in the year 1869:—

Table No. 3, showing the Causes from which Explosions arose in the Year 1869.

Cause of Explosions.	Number of Explosions.	Persons Killed.	Persons Injured.
Malconstruction:— External Firing.............. 11 Collapse of Flue Tubes...... 7 Weak Manhole .... 4 Want of Stays .... 4......	26	28	43
Defective Condition:— External Corrosion .... 8 Internal Corrosion.......... 7......	15	33	56
Overheating through Shortness of Water...	7	10	11
Overheating from the Use of Boiler Compositions	1	0	0
Overheating,—But cause of Overheating requires further Investigation	1	11	7
Cases in which full Particulars have not been Obtained	8	4	9
Total	58	86	126

All boiler explosions may, as a rule, be attributed to the neglect of the boiler maker, the boiler owner, or the boiler minder. Looking at the preceding table, it will be seen that 26 explosions were due to the boiler maker, 15 to the boiler owner, and 7 to the boiler minder. While it is important that it should be known that a large proportion of the explosions that occur are due simply to bad boiler making, it should not be overlooked that the boiler maker is very much under the influence of the boiler owner, and therefore the responsibility must be shared between the two, which gives the boiler maker and the boiler owner together 41 explosions to answer for, against 7 by the boiler minder, or 6 to 1.

The above table also shows how easily these explosions could have been prevented. The 11 explosions due to external firing could have been prevented by the adoption of the Lancashire boiler, in such general use in the cotton mills in this district and from which so few explosions arise. The 7 cases of collapse of flue tubes might have been prevented simply by the addition of encircling hoops, flanged seams, or other suitable strengthening appliances. The 4 weak manholes could have been strengthened with mouth-pieces. The 4 cases of want of stays could have been corrected by due calculation. The 15 plates wasted by external and internal corrosion might have been detected in time to have prevented explosion, by competent examination, while the 7 cases of overheating through shortness of water, though due to neglect of attendants, might, in the majority of cases, if not in all, have been prevented by a liberal complement of fittings, and the adoption of a low water safety-valve. Thus the causes of nearly all explosions are under control, and these disasters, as has been said on so many previous occasions, may, as a rule, be prevented by the exercise of common knowledge and common care.

Simple as the causes of these explosions were, the investigations conducted by coroners with regard to them, were, in the majority of instances, most unsatisfactory, and the verdicts positively mischievous. Too frequently only incompetent witnesses were examined, and explosions resulting from glaring defects in the boilers were pronounced to be *inscrutable* and *inevitable*, in consequence of which, boilers as deadly as those which had given rise to the explosions under consideration were allowed to be worked on without warning, at the peril of the lives of the poor men around them.

Constant reference to these subjects may appear monotonous, but those who are brought face to face with the devastation produced by these catastrophes are stirred with a strong sense of indignation at such evidence on these occasions. In one instance to which reference may be made, six persons were injured, one of them fatally, as well as a woman widowed and a family orphaned, simply by the explosion of a grossly malconstructed boiler, yet, on an investigation by a learned coroner and his jury, the catastrophe was pronounced to be "accidental" and every one connected with it acquitted of responsibility. The man was killed, and he must be buried, but it could not be helped, and there was an end of the whole matter. The owners were at liberty to set to work another boiler, as defective and therefore as deadly as the last, and to work on till another explosion should occur, and other men should be slaughtered, as well as others injured, other women widowed and other children orphaned; when again, by the help of another learned coroner and his jury, the whole transaction would be once more condoned, the boiler pronounced good, the owners careful, and the only remaining duty declared to be to bury the dead out of the sight of the living, and to go on as before. Such is a simple recital of an almost every-day occurrence, and the question arises, how is it that such a state of things is allowed to exist? The answer is a simple one. Those who are killed are only poor stokers who are too friendless and too ignorant to defend themselves. Let seventy-five boiler owners be blown to pieces next year instead of seventy-five of their firemen, then boiler explosions would at once cease to be considered mysterious, the cause of each would become as clear as daylight, and their recurrence would be at once put a stop to. At all events, this association is resolved to be clear in this matter. It has for years investigated the circumstances attending nearly every explosion that has occurred, and circulated broadcast sound information with regard to their cause. It has endeavoured to sweep away all mystery with regard to this subject, and to show steam users how to prevent the explosion of their boilers, and the slaughter of their workpeople; and as long as explosions continue to occur, from the use of glaringly mal-constructed and old worn out boilers, it will persist in circulating as widely as possible full particulars with regard to them, and in declaring that explosions generally are not the result of accident but simply of neglect, and that they might be and ought to be prevented.

SOCIETY OF ENGINEERS.

ENGLISH AND CONTINENTAL INTERCOMMUNICATION.

By Mr. Perry F. Nursey.

(*Continued from page 9*).

Bateman.

The uncertainty of the strata in the bed of the Channel, and the risks of tunnelling under the sea, have led Mr. J. F. Bateman, in conjunction with M Julian J. Rèvy, an Austrian engineer, to propose a cast-iron tube for carrying a railway across the Channel. The distance to be crossed, and the cost to be incurred, undoubtedly require that the mode to be adopted shall be absolutely free from serious doubt and risk, and shall be as evidently capable of accomplishment as the most ordinary mechanical operation. Some degree of uncertainty must exist in every contrivance and speculation; but, unless a scheme can be proposed which will be free from all doubt and objection so far as human knowledge and foresight can extend, it will hardly deserve, and will not probably receive, the support of the public. The various proposals for constructing submarine tubes have been carefully studied by Mr. Bateman and M Rèvy, who have come to the conclusion that none of them are free from serious objections, both on the score of difficulty of construction and the dangers which would attend the operations as proposed. Their object, therefore, has been to devise a scheme by which all difficulties of operating in water should be avoided They propose to lay a tube of cast iron on the bottom of the sea, between coast and coast, to be commenced on one side of the Channel, and to be built up within the inside of a horizontal cylinder or chamber, which shall be constantly pushed forward as the building of the tube proceeds. The chamber within which the tube is to be constructed will be about 80ft. in length, 18ft. internal diameter, and composed of cast iron rings 8in. thick, securely bolted together.

The interior of the bell will be bored out to a cylindrical surface like the inside of a steam cylinder. The tube to be constructed within will consist of cast iron plates in segments 4in. in thickness, connected by flanges bolted together inside the tube, leaving a clear diameter of 13ft. when finished. Surrounding this tube, and forming part of it, will be constructed annular discs or diaphragms the outside circumference of which will accurately fit the interior of the bell. These diaphragms will be furnished with arrangements for making perfectly water-tight joints, for the purpose of excluding sea water and securing a dry chamber within which the various operations for building up the tube and for pressing forward the bell as each ring of the tube is added, will be performed. There will always be three, and generally four, of these water joints contained within the bell. A clear space between the end of the tube and the end or projecting part of the bell of 36ft. will be left as a chamber for the various operations. Within this chamber powerful hydraulic presses, using the built and completed portion of the tube as a fulcrum, will, as each ring is completed, push forward the bell to a sufficient distance to admit the addition of another ring to the tube. The bell will slide over the water-tight joints described, one of which will be left behind as the bell is projected forward, leaving three always in operation against the sea.

The weight of the bell and of the machinery within it, will be a little in excess of the weight of water displaced, and, therefore, the only resistance to be overcome by the hydraulic presses when pushing forward the bell is the friction due to the slight difference in weight and the head or column of water pressing upon the sectional area of the bell against its forward motion. In like manner the specific gravity of the tube will be a little in excess of the weight of water which it displaces; and in order to obtain a firm footing on the bottom of the sea the tube will be weighted by a lining of brick in cement, and for further protection will be tied to the ground by screw piles, which will pass through stuffing boxes in the bottom of the tube. These piles will, during the construction of the tube within the bell chamber, be introduced in the annular space between the outside of the tube and the inside of the bell, and will be screwed into the ground as they are left behind by the progression of the bell. The hydraulic presses and the other hydraulic machinery which will be employed for lifting and fixing the various segments of the tube will be supplied with the power required for working them from accumulators on shore, on Sir William Armstrong's system, and the supply of fresh air required for the sustenance of the workmen employed within the bell and within the tube will be insured also by steam power on shore. As the tube is completed the rails will be laid within it for the trains or wagons to be employed in bringing up segments of the rings as they may be required for the construction of the tube, and for taking back the waste water from the hydraulic presses, or any water from leakage during the construction.

The tube will be formed of rings of 10ft. in length, each ring consisting of six segments, all precisely alike, turned and faced at the flanges or joints, and fitted together on shore previous to being taken into the bell, so that on their arrival the segments may, with certainty and precision, be attached to each other. Every detail of construction has been designed, and, so far as the authors of this project can see, no contingency has been left unprovided for. The possibility of injury by anchors or wrecks, or submarine currents, has also been investigated. The tube when laid will be secure from all dangers arising from such causes.

The building of the tube will be commenced on dry land above the level of the sea, and will be gradually submerged as the tube lengthens. The operations on dry land will be attended with more difficulty than those under water, but all these circumstances have been carefully considered and provided for. The rings forming the tube will be made by special machinery, to be expressly constructed for facilitating the work and economising the cost. This machinery is all designed and specified. The first half mile will test the feasibility of construction, for that will have to be built both above and under water. When once fairly under water the progress should be rapid, and it is estimated that the whole undertaking may be easily completed in five years from the commencement.

The precise line to be taken betwixt the English and French coasts can hardly be determined without a more minute survey of the bottom of the Channel than at present exists. It will probably be between a point in close proximity to Dover on the English coast, and a point in close proximity to Cape Grisnez on the French coast. From an examination of the Admiralty charts, and of such information as at present exists, the sea bed on this line appears to be the most uniform and level, and while free from hard rocks and broken ground, to consist of coarse sand, gravel, and clay. The average depth of water is about 110ft., the maximum about 200ft. On the line suggested the water increases in depth on both sides of the Channel more rapidly than elsewhere, although in no instance will the gradient be more than about 1 in 100. The tube, when completed, will occupy about 18ft. in depth above the present bottom of the sea. Up to the point on each shore at which the depth of water above the top of the tube would reach, say, 30ft. at low water, an open pier or other protection would have to be constructed for the purpose of pointing out its position, and of preventing vessels striking against the tube. These piers may be rendered subservient to harbour improvements. The tube at each end would gradually emerge from the water, and on arriving above the level of the sea would be connected with the existing railway systems, so that the same carriage may travel all the way from London to Paris.

The distance across the Channel on the line chosen is about twenty-two miles. The tube as proposed is large enough for the passage of carriages of the present ordinary construction, and to avoid the objections to the use of locomotives in a tube of so great a length, and the nuisance which would be thereby created, and taking advantage of the perfectly circular form which the mechanical operation of turning, facing, &c., will insure, it is proposed to work the traffic by pneumatic pressure. The air will be exhausted on one side of the train and forced in on the other, and so the required difference of pressure will be given for carrying the train through at any determined speed. Powerful steam engines, with the necessary apparatus for exhausting and forcing the air into the tube, will be erected on shore at each end; and, supposing one tube only to exist, the traffic will be worked alternately in each direction. This system of working the traffic will secure a constant supply of the purest air, which will accompany every train.

The estimated cost of the whole undertaking, including the stations and approaches at each end, the engine power and machinery, the interest of outlay during construction, and engineering superintendence, with a large margin for contingencies, is £8,000,000.

Grantham.

Mr. John Grantham's proposition for improving the communication between England and France is to turn the present system to account, and to make an efficient means of transit whilst the more elaborate schemes are being perfected and rendered practical. Mr. Grantham proposes steamships 400ft. long, 45ft. beam, and 600 nominal horse-power, to be built of steel, and to draw 6ft. 6in. water, and to steer from either end, to avoid the necessity of turning. The lower part of the ship is to be cellular, so as to avoid the danger of sinking if injured by a collision, and to add to her strength. This cellular portion is 6ft. in depth; over it would be the main saloons, these to be 10ft. in height, and provided with ample accommodation for reclining in bad weather; good refreshment tables also would be provided, with light and air to avoid that gloom and closeness so painful to landsmen when on board ship. Between the paddle boxes would be a promenade deck, 100ft. long, on the extremities of which would be the houses from which the vessel would be steered. To strengthen her admidships, with the least amount of weight, there would be provided four open longitudinal girders, about 250ft. long, so arranged as to cause very little obstruction on the ship, and longitudinal bulkheads, about 90ft. long, would run through the engine compartment. In addition to these precautions the plates of the sides would be extended up, and form the inner side of the paddle-box, drawn off towards the ends at the same angle as the trussed girders.

In order to facilitate the transfer of passengers and luggage from the piers to the ship, wide and ample means are provided at three different elevations to receive the stages from the shore. The lowest of these is on the level of the main deck, the next is on the level of the promenade deck, and the upper one is on the paddle-boxes or on the captain's platform; so that, whatever should be the state of the tide, the stages may rest on the top of the piers, and be nearly level. On the piers are to be erected sheds, under which the trains are to run, as in ordinary railway stations, to be well enclosed and lighted, so that but little delay or discomfort would arise. The staircases leading from the promenade platform to the deck should be easy, wide, well-lighted, and sheltered. The great bulk of the luggage would be stowed in trucks, the bodies hoisted by hydraulic cranes on to the deck, and again lifted off on the other side and placed on wheels provided for them. In all this there is no novelty introduced; all that is proposed may be seen in operation in other places. The only question that can be raised is as to the facility of working a vessel, such as is here described, in and out of the harbours. For experience in this Mr. Grantham refers to the American steamers, which are managed with wonderful precision. These vessels have in some instances exceeded 400ft. in length. Those on the rivers draw 5ft. and 6ft. of water, and those which put to sea vary from 7ft. to 10ft.: but all are of immense height out of the water, the wheel-houses of some being upwards of 40ft. above the water-line. Mr. Grantham's vessel, though drawing only 6ft. 6in., will not exceed 15ft. above the water-lines at the ends. Long vessels steer much more steadily in heavy weather than short ones, and will, therefore, enter such harbours as Calais or Boulogne with more safety than the present vessels, and, when fairly entered, there is time to bring them to a standstill before reaching their berths.

Mr. Grantham gives the following reasons for not adopting a vessel in which the trains should be carried bodily across:—First, there is the necessity of placing the vessel in a position of perfect stillness before taking trains on or off the ship. This involves new harbours on each side, with dock gates and breakwaters to protect them. Secondly, the large ships necessary to carry the trains will take a long time in bad weather before they can be placed in position and the gates closed. Thirdly, very few persons would remain in the carriages when being put on board, and in the event of sea-sickness, they could not be allowed to remain, so that the passengers must have time to leave the carriages and walk on board. Lastly, the large outlay in forming the harbours, appliances for shipping the trains, and the extra cost of the ships, together with the heavy cost of working them.

Boutet—1869.

M. Boutet selects a point on the Dover hills near the Shakespeare Cliff for the commencement of the International Bridge, which is to touch the coast of France at Blanc Nez, a short distance from Calais, at which place the cliffs are about the same height as those on the English coast. These cliffs, at either extremity rising nearly 400ft. above the level of the sea, serve as abutments for the proposed viaduct. To protect them against the destructive action of rain, winds, and frost, they will be faced with a solid construction of dressed stone. The project depends in effect on two remarkable innovations in the construction and establishment of the piers—of which there will be 29—and girders. In addition to the considerable height to which the former rise above the water (120 yards), the bases of the piers are sunk to the bottom at a depth varying from 28 yards to 52 yards. The centre pier will be half as large again as the others. All the pieces composing the work are of cast iron.

As such ponderous piers could not be erected by the ordinary means, M. Boutet proposes to construct on the shore their lower parts or bases to a height sufficient to rise ten yards above high water, and as soon as the iron skeleton is put together and bolted a number of large sheet iron buoys are distributed about the surface of the base. At low water the metallic framework thus prepared is made to slide upon the shore to low water mark. The tide in rising raises this raft or base of iron lightened by the buoys and floats it. A tug steamer then removes it to its place, previously indicated by one of a line of buoys attached to an iron cable stretched across the Straits at a depth of eighteen yards. By raising one of the buoys attached to the raft it is made to descend very slowly, the top being just above the level of the sea when the base touches the bottom. The base of the pier is provided with large screws or spiral feet, which on being turned bind it firmly to the solid bed of the sea, and serve to establish the level if necessary.

Next with regard to the superstructure, M. Boutet has hit upon a plan whereby the difficulties of transport, &c., are overcome. He constructs rigid beams endowed with great powers of resistance of a weight relatively small, and capable of being placed in position piece by piece, by the aid of a system of scaffolding constructed as follows:—Between the abutment on the shore and the first large pier three temporary piers are placed at equal distances. This done there are stretched in parallel lines a number of wire cables two metres (*i.e.*, two yards six inches) apart. They are connected and bound together by ties made of smaller cables, which interlace the large ones and hold each in its place. The whole forms a truss of sixty three yards wide. The truss thus made is covered by a wooden flooring, a guard is fixed on each side, and there is at once obtained a service bridge upon which scaffolding is erected to support the roadway of the bridge during its construction, the scaffolding being always at a sufficient height above the sea to allow the largest vessels to pass under it. Upon such scaffolding are supported the wires forming the roadway of the bridge, each of which is strained as nearly to a right line as possible, after which smaller cables are interwoven, bracing together the main cables and holding them firmly in their places. Each cable is composed of eight iron wires parallel to each other, and bound together at intervals by strong wire collars. The straining of the large cables is to be managed by means of weights, which are removed after the proper degree of tension has been attained, and the cables fastened down to the tops of the piers. For example, we will assume the cable to be fixed at the abutment, and laid loosely over the other piles, the weight would then be applied to the length of the cable between the first and second piers. This would bring the length between the abutment and the first pier taut, and it would be made fast to the first pier. The weight would then be removed to the cable between the second and third piers, and the process would be repeated until every span of cable was stretched to its proper limit. The cables are carried without a break over the tops of the piers; each cable therefore will be twenty-one miles long. Above and below these cables are fastened beams of timber, over which the permanent way will be fixed. The author is informed that Mr. Ordish has pronounced that a portion of the scheme relating to the piers to be practicable, and the method of floating the bases exceedingly ingenious. Another eminent engineer, the chief of one of our leading railways, but whose name the author is not at liberty to mention, has examined M. Boutet's plans for the superstructure, and states that the scheme is perfectly feasible. He, however, sees a difficulty about the piers, but, as we have it on the authority of Mr. Ordish that the piers are practicable, we may conclude the whole structure to be so. The bridge is estimated to cost £8,000,000, and to occupy three years in completing. It is stated that experiments in progress give reason to expect that this estimate will not be exceeded.

Colburn.

Mr. Zerah Colburn has recently proposed a novel method of facilitating the laying of a tube across the bed of the Channel. He has worked out all the details, but inasmuch as the idea forms the subject of a pending patent, only a general outline of the proposition can be given. He proposes to construct a dry dock on the coast at a point where the tube is to be carried across. This dock is to be any reasonable length, from a thousand feet to a mile, only a few feet wider than the outer diameter of the tube. The sections of the tubes are to be united together in this dock, the seaward end being fitted with a water-tight bulkhead and projecting through a water-tight opening in the dock gates. When a length of (say) a thousand feet of tubing was ready the rear end would be fitted with a bulkhead, the water admitted into the dock, and the tube slowly towed or floated out until the last section reached the dock gates. The gates would then be closed, the water pumped out, and the work proceeded with as before. On reaching the opposite shore the tube, after being made secure, is to be lined with brick in cement, and rails laid, and in other respects the work is to be completed.

Parsons.

A pontoon vessel, of shallow draught, for the Channel passage, has recently been proposed by Mr. J. H. Parsons. He connects four pontoons together by cross girders, leaving a waterway between the pontoons for the paddles, of which there are to be six—three forward and three aft. The boilers, coal bunkers, &c., are to be placed in the centre of the vessel, and the engines at each end. In the deck arrangement the idea is to have a sleeping and a general saloon separate from each other. A clear passage is to be left from stem to stern for working the vessel and for a promenade for passengers. This vessel, it is contended, would be rendered independent of the tide in crossing the bar at Boulogne, and would make the service direct instead of tidal, as at present. The author believes that Mr. W. Bridges Adams has also proposed a somewhat similar vessel to that of Mr. Parsons.

Waring.

The present paper would be incomplete, as far as the author's knowledge extends, where he to omit to mention a proposition by Messrs. Waring to effect the Channel passage. But what that proposition is the author cannot say, as, on inquiry at Messrs. Waring's office, the representative of that firm could only say that they "had a concession." What that concession was for, whether for a tunnel, a tube, a ferry, an embankment, a bridge, or an overhead railway, the author cannot say, inasmuch as, to the author's inquiries on this point, the gentleman alluded to was specially reticent and painfully mysterious.

As an embankment has been proposed as a means of facilitating the means of communication between London and the Continent, it may here be briefly referred to. An embankment, however, appears to be about the worst possible solution to the problem, firstly, because of the difficulty of carrying it out, and secondly, because of the tremendous loss of property that it would cause.

Mr. W. H. Barlow has proposed a submerged railway, but the particulars of this scheme have not come under the author's notice.

Mr. Charles Boyd proposes a marine viaduct from Dover to Cape Grisnez, constructed with iron girders on 190 towers, 500ft. apart, and 500 feet above the sea, and he estimates the cost of such a bridge at £30,000,000.

Mr. Hawkins Simpson has addressed the Board of Trade on the subject of working a submarine tunnel on a pneumatic system, which he has termed his "Eolian system," for which he claims cheapness, expedition, superior ventilation, and greater utility.

Mr. Alexander Vacherot has a scheme, on which he has been engaged several years, and which he laid before the Emperor of the French in 1856, for laying on the bed of the sea a tunnel made or formed of concrete, so as to form, when completed, a monolith. He would construct it on the shore, and draw it down to its place in sections.

Estimates.

It is of course taken for granted that the adoption of either tunnel, tube, or bridge, would prove a success commercially. But as this is an important point, and one upon the proof of which any project must be dependent, it may be as well to state a few facts in support of the argument that such an undertaking will pay. It, however, needs not that very much be said upon this point, for as soon as England is directly united with the European Continent, practical advantages of incalculable value will result. The resources of each country, and mutual exchange of produce, will be developed to a degree of which it is impossible to form anything like a correct idea. Mr. Chalmers went very carefully into the subject of the probable revenues to be derived from the establishment of a Channel railway. Writing in 1867, and referring to his estimate, he says:—"I published these figures in a brief prospectus of this project five years ago, and I see no reason to alter them now, unless to increase them. After I adopted them I became acquainted with the work of M. de Gamond, and, on comparing figures, found a wonderful coincidence in the items of freight and passengers, his being £1,041,666 13s. 4d., and mine £1,049,375. He seems to have overlooked the mails* as a source of revenue: his figures were compiled in 1856, and based on the actual business then done between England and the Continent, and as he could not have foreseen the impetus that has since been given to traffic between England and France by the recent Treaty of Commerce, and by the change in the passport system, his figures are more sanguine than mine, compiled in 1861, after these important changes had actually taken place."

Mr. Chalmers estimates the probable revenue as follows:—2,500 tons freight daily, or 912,500 per annum, at 12s. 6d., £570,312 10s.; 1,500 passengers daily each way, or 1,095,000 per annum, at 8s. 9d., £479,062 10s. mails, express freight, coin and bullion, extra baggage, &c. (say) £250,645; total annual revenue, £1,300,000.

These figures, he observes, may appear too high to those who have overlooked the affinity between improved means of transit and the increase of traffic resulting therefrom. In the infancy of railway enterprise the anticipated traffic on a given line was based upon the business done by stage coaches and wagons of the day. It needs not that we compare the anticipated with the actual railway traffic, but we should bear in mind that our experience in that case did not prevent our falling into a similar error in the case of ocean steamers, though fleet after fleet of these vessels have taken their places on the ocean, each creating for itself a trade where none such existed before. Between 1820 and 1830, in the good old times of sailing packets, the number of travellers between England and the Continent did not exceed 80,000 per annum. The establishing of a regular steamboat service raised the number in twelve years to 350,000, and since the introduction of railways it has arisen to upwards of a million. This great increase is not to be attributed to the increase of the populations, but mainly to these improvements; and the effects that would result from the completion of any work connecting England with the Continent would be even greater than were produced by those two important revolutions in locomotion, which respectively raised the figures from 80,000 to 350,000, and from the latter to upwards of a million.

In confirmation of these views, we find Captain Tyler stating, in a recent report upon the improvement of the means of communication between England and France, that, omitting from consideration the ports of Hamburgh, Rotterdam, Antwerp, and Ostend, the passenger traffic between England and France for the year 1868 amounted to 309,179 altogether; 111,633 passenger having travelled by Calais, 109,006 by Boulogne, 11,371 by Dieppe, and 17,169 by Havre. A large proportion of these, namely, 40,111, crossed the Channel in the month of August, as against 12,946 in January, and 13,514 in February. In the year 1867, of the Paris Exhibition, the numbers were 454,350 altogether; 192,837 having travelled by Calais, 146,226 by Boulogne, 86,914 by Dieppe, and 21,373 by Havre. Of these, 84,684 crossed in August, against 13,163 in January, and 13,721 in February. Captain Tyler observes that in addition to the ordinary annual increase, which is considerable, there would naturally be a very large augmentation in these numbers if better arrangements were made for crossing the Channel.

Conclusion.

Looking broadly at the schemes which present the most reasonable features, and irrespective of their engineering merits in detail, it appears to the author that, of tunnel schemes, that of Mr. Remington for driving through the Wealdon formation would be attended with less danger than that of Mr. Hawkshaw, which it is proposed to carry through the chalk. Of the methods of connecting the two shores by tubes along the bed of the channel, that of Mr. Bateman certainly appears the most practicable. If these tubes could be constructed in a dry dock and drawn gradually over upon Mr. Colbourn's method, it would be a very summary method of settling the question, as Mr. Colbourn assures the author he could effect the connection in three months, although, he admits, at a great cost. But, both in subterraneous and subaqueous works, there is an admitted possible risk. In the former, there is the contingency of flooding from the nature of the soil, whilst, in the latter, some of the operations would be dependent on comparatively delicate arrangements. The bridge scheme has also its perils of storms and tempests, but there appears to be a possibility of guarding against the consequences of these more readily than against the insidious advances of a great head of water. The bridge scheme, too, has had its substructure approved by one independent engineer, and its superstructure by another. As far, then, as we have at present advanced, the bridge scheme appears to present the most reasonable chance of success. But either a tunnel, a tube, or a bridge would be the work of perhaps eight or ten years, for the author does not think the various projectors have allowed sufficient time for the contingencies that would arise in the course of carrying out works of such unparalleled magnitude. We must, therefore, turn to some plan by which the existing requirements of the travelling public can be promptly and inexpensively met.

Captain Tyler, R.E., has examined the English and French coasts and investigated the various projects, and has reported to the board of trade thereon. Referring to Mr. Fowler's plan for improved steam vessels and harbour accommodation, Captain Tyler observes that the project would require some modifications in detail, and that it is a question whether it would be worth while to ferry the railway carriages as well as the passengers across the channel. But the main features of an improved harbour at Dover and a new harbour south of Cape Grisnez are sound, if means can be found for meeting so great an expense.

With regard to Mr. Grantham's proposition to utilise the existing harbours by vessels of light draught, Captain Tyler states that it is asserted by some of the officers engaged in the performance of these services that vessels of the class now employed are, upon the whole, the safest that could be devised for the particulars required of them. It is argued that the sea-passage, in which greater length and size might lead to increased comfort, is comparatively short, while the entrance of the French harbours, by day and night, in certain states of the weather, which is already the more difficult and dangerous part of the service, would be attended with still greater disadvantages. The existing vessels are fitted to encounter any weather with which they can meet in the channel, and are handy for entering the harbours, while longer vessels would be exposed to increased risk at the moment of entering the harbours. The bow of a long vessels getting under the shelter of one pier, and a heavy sea striking her on the quarter, she might be driven against the other pier. The above argument, therefore, tells in favour of the construction of an extended pier at Boulogne, as proposed some time since by Mr. Brunlees to be used on the French, in combination with the pier at Dover on the English coast, for an improved channel service.

The matter, then, in general terms stands thus:—The steam packet service between England and France is greatly in need of improvement. This service is important in its character, and the existing steamers, restricted as to their dimensions for want of better pier and harbour accommodation, are not proportionate to the importance of the service. Larger vessels, with less movement in rough weather, more shelter, and better accommodation generally, would do much to mitigate the discomforts of the sea-passage; and even contemplating the successful issue of a tunnel or bridge project, these improvements are much required, and should be effected in the meantime. But larger vessels cannot be employed for a fixed service until better provision is made for embarking and disembarking passengers, especially on the French coast. The pier at Dover is not only ready, but has frequently been used for military transport-vessels of the largest size, though certain improvements are required in the jetties for greater convenience in embarkation and disembarkation. The difficulties in the way of fitting the harbour of Calais for the reception at all times of larger vessels are great, but by a judicious extension of the west pier at Boulogne similar accommodation might be provided on the French side. Captain Tyler estimates that at a cost of about £100,000 at Dover, and £500,000 at Boulogne, the desired object might, apparently, be attained in the most economical and most expeditious manner. By the adoption of steamers capable of moving with equal facility in either direction the difficulties incidental to turning round in small harbours may be avoided; and the existing harbours at Dover and Boulogne might, with certain modifications, be made available, to some extent, for improved vessels.

Whatever be the plan ultimately decided upon for connecting England and France in a direct manner, such a plan must have the best wishes of those here present this evening, as well as those of the whole civilised world. It

* Mr. Chalmers and M. de Gamond have both omitted the revenue which would now be derivable from the electric telegraph companies.

should not be so much the honour of adopting this, that, or the other scheme that should influence us, as the reflection that the accomplishment of the object will be attended by advantages to the nations of the earth. In former times, when Europe was regarded mainly as a theatre of war, it was, perhaps, no disadvantage for this country to be separated from it. But, since the introduction of steam has so completely changed the character of marine locomotion, any advantage formerly arising in this respect from our insular position has been materially diminished, and, in the present day, it is continental commerce from which we are separated and not continental wars.

THE INSTITUTION OF CIVIL ENGINEERS.

ON THE STATISTICS OF RAILWAY EXPENDITURE AND INCOME, AND THEIR BEARING ON FUTURE RAILWAY POLICY AND MANAGEMENT.

By Mr. John Thornhill Harrison, M. Inst. C.E.

It was suggested that the existing lull in railway extension offered a favourable occasion for reviewing the past progess and future policy of the system; and that the most important points for consideration were the development of its resources, the diminution of the annual expenditure, and the circumstances under which branch lines, inexpensively constructed, were likely to prove a remunerative investment for capital. The returns now made to the Board of Trade supplied reliable information on most points of interest. Diagrams were exhibited, giving a synopsis of this information for twenty of the principal railways in England and Scotland, which represented about 85 per cent. of the entire capital expended in the United Kingdom. The peculiarities of traffic gave a distinctive character to each line, and the whole were classified according to the proportion of income from passengers. The most striking feature of this traffic was the large numerical proportion of third-class passengers, and, with few exceptions, they yielded the largest amount of revenue. The circumstances which seemed to affect the number of persons travelling first, second and third class were considered; and whilst it was admitted that each locality required a separate study, it was thought that there were probably some general principles which, with allowances for variable circumstances, might prove useful guides; and it was deduced that where low fares filled the trains, a moderate difference in them effectually sorted the passengers, and tended to increase the demand for first and second class tickets for long journeys. Attention was then drawn to the goods traffic, to the great importance of favourable gradients where the mineral traffic was in excess, and to the probable advantage of improved communication between the Northern and Welsh coal fields and the metropolis.

On the question of the further extension of railways, it was urged that many lines might be constructed at a cost of from £3,000 to £5,000 per mile, provided the landowners would sell their land for the purpose at the ordinary market value, that the Board of Trade would allow level crossings, and that gradients as steep as 1 in 20 or 1 in 30 were adopted. Also, that such lines, economically worked with light engines and low traffic expenses, would prove at the same time beneficial as feeders to the main lines, and of social and pecuniary importance to many resident owners and occupiers of the soil. It was shown that the train mileage receipts depended upon the character of the traffic, that when the receipts from passengers and merchandise predominated they were high, but lowest when minerals formed a large proportion of it, which was in a great measure accounted for by the wagons generally running empty in one direction.

Attention was next directed to the striking similarity on the different lines of the per centage of expenditure on the gross receipts, which averaged about 48.4 per cent.,—and the combined expenditure for maintenance, rolling stock, and locomotive power, which generally exceeded 50 per cent. of the total expenditure, the other heavy item being about 30 per cent. for traffic expenses. Omitting the Metropolitan and the Cornwall lines, the maintenance of way for twelve months varied from 6¼d. to 9d. per train mile, or deducting £56 per mile for constants, the cost varied from 4½d. to 6½d., averaging about 5½d. per train mile. Carriage repairs varied from 1½d. to 2½d. per train mile with few exceptions The cost of repairs to goods trucks varied very greatly, and was dependent not only on the nature of the traffic, but on the number of trucks which belonged to the railway company. A great number of trucks in the coal trade were the property of the colliery owners. The total locomotive charges were generally from 8d. to 9d. per train mile. The repairs amounted to about 3½d. per train mile, when the mineral traffic was heavy, and from 2½d. to 3d. on the passenger lines south of London. Under the head of running expenses, the item of wages was strikingly similar on all the lines, being about 2¼d. per train mile. The cost of fuel per train mile varied greatly, but it was dependent quite as much on the value of the fuel per ton as on the quantity consumed. On the southern lines, where the consumption was small, the cost was 3d. or 4d. per train mile, whilst on the northern lines, where the consumption per train mile was large, but the price was small, it was only about 2d. The actual consumption of fuel might be taken on the passenger lines at 30lbs., on the extensive systems of the Great Western, the North Western, and the Great Northern at 40lbs., and on other lines having a mixed goods and mineral traffic at 50lbs., whilst on the mineral lines, where the amount of shunting and piloting was very large, it rose to about 60lbs. per train mile. The percentage of net revenue on the total capital expended exceeded 5 per cent. per annum on eight lines; was between 4 and 5 per cent. on four; 3½ to 4 on other four; 3 to 3½ on two; and only in two cases was it under 3 per cent. This percentage was influenced by the cost of construction and the character of the traffic, and showed the importance of their consideration. The amount available for dividend was dependent on the percentage on the total capital. When this percentage fell below 4½ per cent. the stockholders' dividend was diminished to supply the deficiency, and *vice versa*; it depended most on the burdens to be borne; but where lines could *bona fide* pay all their engagements, and have a surplus to divide, the elasticity of the railway system seemed to promise at an early date a fair rate of dividend.

Two large funds for investment of capital were next considered; the National Debt, which amounted to 750 millions sterling, and gave a return of 26½ millions per annum, or 3½ per cent., which was a burden on the industry and capital of the country; and the capital expended on railways, which amounted to 500 millions sterling, giving a return of 20 millions, or 4 per cent. per annum; whilst a sum nearly equal to the interest on the National Debt was annually expended in labour and materials. It appeared that 54 per cent. of the railway capital had been expended since 1849, in which year it amounted to £228,747,779; whereas in 1867 it was £502,262,887. The length of railways in operation had been more than doubled, being 6032 in 1849, and 14,247 in 1867. The length of double line was increased from 5034 to 7844 miles, or 56 per cent.; whilst the single lines had been increased 542 per cent., or from 998 miles in 1848, to 6403 miles in 1867. Notwithstanding this the cost per mile was maintained at from £33,000 to £36,000 per annum. This was explained by the general traffic having increased 240 per cent., whilst the capital expenditure was only 120 per cent. This augmented traffic demanded extensive increase of rolling stock, sidings, and station accommodation, especially for goods. The traffic was still largely on the increase, and this would necessarily delay the closing of the capital accounts, which was desirable. The burdens on railway property, as they affected the original shareholder, and the proposals for relieving these burdens to some extent, were next considered. One of these proposals was, that Government should take upon itself the responsibility of the loan capital at an equitable price, and it was urged that as they could borrow money at a low rate of interest, they might benefit the railway companies and the public by an arrangement for extinguishing the loans and reducing the fares and rates. The other proposal was, that the well-established railway companies should associate together for the purpose, and issue their joint stock in exchange for loans contracted by any of the associated companies. The objection to this was, on the part of some companies, that they were consolidating their stock, and taking other steps to improve their position, which position could not be improved by such an association. The undoubted value of railway property fully justified some attempt to form a railway fund system, in which trust money might be deposited and be readily redeemed in the public market when wanted.

After reviewing the means of increasing income and reducing the expenditure, the author stated that the subject was not brought forward with a view of advancing any preconceived opinions, but to stimulate a discussion which could not fail to prove useful to all interested in the commercial success of the railway system, if the many intelligent railway managers who were in possession of the most useful information took part in it.

At the monthly ballot, the following candidates were balloted for and declared to be duly elected:—As Members: Messrs. G. Allan, A. W. Craven, C. C. Greenwell, J. Hendry, S. G. Purchas, and J. B. Simpson; and as Associates: Captain W. H. Beckett, Messrs. H. Hakewill, J. I. Hopkins, T. Horn, W. C. Luard, R. E. Middleton, F. Morris, G. J. Morrison, P. A. H. Noyes, Stud. Inst C.E.; A. C. Pain, J. T. Potts, E. T. Q. de Rochemont, W. Stead, and E. Wilson.

A report was brought up from the Council stating that, under the provisions of Sect. IV. of the Bye-laws, the following candidates had been admitted students of the Institution since the last announcement:—Messrs. T. B. Fry, W. Greenwood, G. G. M. Hardingham, J. Heinig, S. Preston, T. B. West, and A. P. Wright.

SUBMARINE TELEGRAPHS.

Submarine telegraphy, which may be called the youngest branch of engineering, has been the first to show the signs of recovery from the long stagnation in the profession. The activity which here prevails is owing to a large extent, no doubt, to the avidity with which the shares in those lines which were first ventured to be proposed, were taken up. When the required capital is so freely obtained there are invariably plenty of schemes good, bad and indifferent, brought forward with the hope of boing equally successful upon the principle, we presume, of making the supply equal the demand. But when, as in many instances lately brought forward, the promoters, in order to keep up that supply, are reduced to proposing extensive lines of telegraph only to compete with others already made or in course of construction, it is evident that whatever other remuneration may be calculated upon, that of the "original shareholder" is entirely left out of the question. Admitting, as all must admit, the reality of the demand for telegraphs by men engaged in business, their frequently high money value to the merchant, and their sometimes priceless value to the individual, the proposal to lay down costly lines between far distant countries will yet naturally suggest the question whether they will pay. Can they be profitably worked at rates which will bring them within the reach of a large numbers of customers? It is calculated that on an average a commercial message consists of 30 words; sixteen words per minute is the rate at which a message can be transmitted and received by skilful operators, so that 30 messages can be sent in an hour. On account of the differences of time between distant parts of the earth there can be no division of the 24 hours into day and night, and ocean cables must be worked continuously by relays of clerks. In order to allow for the intervals between the conclusion of one message and the commencement of another, the day is considered to consist of 20 hours; in which, therefore, 600 messages can be sent or received. At the present rate charged across the Atlantic, these 600 messages of 30 words each would bring in a return of £2,700, and thus, allowing 300 working days in the year, a single cable to America might earn a possible annual revenue of £710,000. As a matter of fact, the shareholders of one of the Atlantic cables have already had their capital nearly or entirely restored to them; and it is no longer doubtful that the commerce between any two great centres of activity will pay for telegrams at a scale which will render the wires very remunerative. When a cable is once paid for, and when a reserve fund has been formed from which, if damaged, it can be repaired or replaced, it will become the natural interest and the true policy of the owners to encourage its use by cheapness, and to make it the ordinary medium of much of the private intelligence that is now sent almost entirely through the post.

In order to show how completely this view has been accepted by capitalists, and by how large a stake they have testified their belief in its correctness, it is worth while to subjoin a tabular statement of the ocean telegraphs now constructed or contracted for, and of the sums used or subscribed to complete them. Irrespectively of some short cables in the seas of Northern Europe, the list would be as under:—

Name of Company, &c.	Capital.	Length of Cable.	When Contract was or is to be completed.	Date of forming of Company.
	£	Miles.		
Anglo-American Telegraph Company	1,360,000 ('65)	1,898	Sept. 8, 1865	March, 1865
(Two cables, Valentia to Newfoundland)	600,000 ('66)	1,852	July 27, 1866	
French Atlantic Telegraph Co. (Brest to Boston)...........	1,200,000	1,333	July 20, 1869	July, 1868
Falmouth, Gibraltar, and Malta Telegraph Company ...	660,000	2,456	May 31, 1870	July, 1869
Anglo - Mediterranean Telegraph Co. (Malta to Alexandria)	260,000	900	October, 1868	May, 1868
British Indian Telegraph Co. (Suez to Bombay)	1,200,000	3,600	April, 1870	January, 1869
British Indian Extension Co. (Ceylon to Penang and Singapore)	460,000	1,756	Before end of 1870	October, 1869
China Submarine Telegraph Co. (Singapore to Hongkong and Shanghai)	525,000	2,040	June, 1871	Dec. 10, 1869
British Australian Telegraph Co. (Singapore to Java and Port Darwin)	660,000	1,726 800 land	Before end of 1871	January, 1870
Total capitals, £6,925,000		20,961—Total miles.		

Several years' experience of long land lines has demonstrated that, though cheaper in the beginning, they are vastly more uncertain and consequently utterly valueless in comparison with the more costly submarine lines. Thus the Russian lines upon which we had until lately to depend for telegraphic communication with the East are notoriously irregular.

The vast regions to the north of China have a climate of great severity, disturbed by frequent and violent storms. The injury done to telegraphs by these natural influences is now attracting the attention of engineers, and is found to entail expense and inconvenience, even in civilized and populous countries. Even in its passage through Persia the line to India was frequently wilfully damaged. A fall in the price of cotton was at one time almost invariably followed by an interruption of communication. It was supposed that cotton-holders had distant agents, say at Teheran or Tabreez, whose task it was, on the arrival of certain intelligence, to send off two or three rascals, mounted on dromedaries, that they might reach the wires, and armed with nippers that they might cut them. The Chinese would not be slow to learn and adopt similar contrivances; and, between roguery, snowstorms, and savages, a wire extending over thousands of miles in Siberia and Tartary could hardly be expected to subserve, with any steadiness and safety, the perpetual demands of business.

The other alternative is by the submarine cables now laid or in course of construction. When the Great Eastern returns from Aden she will immediately carry out a cable to extend from Falmouth, by way of Gibraltar, to Malta, where it will join the present Malta and Alexandria cable, and will complete the direct line from England to Bombay. From the southernmost point of Ceylon a cable will then be carried to Singapore, touching at Penang and Malacca. From Singapore one line will proceed north to Hongkong, Amoy, and Shanghai, and another south to Batavia and through Java to Port Darwin, at the north of Australia. Thence a coast line will be taken round the eastern side of the Australian continent to Burketown, Cardwell, Rockhampton, Brisbane and Sydney, uniting with the telegraph from Sydney to Melbourne and Adelaide, and with that from Melbourne to Launceston and Hobart Town. From Hobart Town a cable is projected to New Zealand; and, to complete the circle round the world, some American capitalists have been negotiating for another across the Pacific, from China to California, by way of Japan and Alaska. Besides these there are the cables to the West Indies and South America in course of construction, so that in the course of a very few years we may expect to be able to communicate by telegraph to almost every part of the civilized world.

THE WARSOP AERO-STEAM ENGINE.

At the meeting of the British Association at Exeter last August, a paper was read by Mr. Eaton, of Nottingham, in which was described a system of using air in conjunction with steam in high pressure engines. This plan was invented by Mr. George Warsop, a Nottingham mechanic, who, with the assistance of Mr. Eaton, took out a patent for the arrangement, and carried on a series of experiments to test its value. An account of some of these experiments was given in the paper, already referred to, read before the British Association, but at that time the trials were scarcely of a character to enable engineers to form a decided opinion as to its merits. Since then, however, a variety of trials have been made which appear to show a considerable advantage obtained by this system over the ordinary engine working with plain steam. The peculiarity of the arrangement as described at the meeting of the British Association, was the addition of an air-pump to an ordinary high-pressure steam engine. Air condensed from this pump was driven into a tube, which was carried at first within the exhaust steam-pipe, next in a spiral course within the funnel, and which finally entered at the lower part of the boiler, where it terminated in a large circle, pierced by numerous very fine openings, from which the compressed and heated air bubbled up through the water, imparting heat to it and breaking up its cohesion. Mr. Warsop conceived that the air would not only preserve and convey to the water a large amount of heat that would otherwise be wasted, but that the bubbles would enormously increase the surface on which heat could act, and would represent, in effect, an infinite number of minute tubes. He thus expected to boil the water with less expenditure of coal, and the results of his experiments, after preliminary difficulties had been overcome, were sufficiently satisfactory to justify expectations of great ultimate success.

Messrs. Easton and Amos have lately concluded a tolerably complete series of experiments with a stationary engine set up at Nottingham. As the air-pump could be put out of gear at any time, these experiments were made upon the same engine with and without the addition of the Warsop system. The engine was on the ordinary overhead direct action system, having the usual slide-valve motion, and the addition of a compressing air-pump, worked by a throw in the crank shaft. A feed-pump of the common kind supplied the boiler, which was of the Cornish multitubular description, seated in brickwork, and furnished with the usual mountings and fittings. The air, on leaving the compressing pump, was passed into a coil enclosed within the exhaust-pipe. Passing from this into another coil descending within the chimney, it entered a line of pipes contained in the flue of the boiler. Traversing a coil in the smoke box so arranged as to allow the boiler tubes to be freely cleaned, it passed again through the flue on its return, and entered the boiler by means of a check valve at the front. From this it made its passage into the water through a perforated distributing pipe beneath the internal flue, allowing it to escape in numerous small jets. The air was thus entirely heated by the waste gases, on their passage to the chimney, and by the heat taken up from the exhaust steam. A Prony break, with all the latest improvements, was employed as the measure of useful work done; and the experiments were conducted in accordance with the following programme:—

1. To get the engine into regular and steady working order, the firing even and constant, and then to ascertain what load upon the friction break

could be properly maintained; the starting valve being fully open and the boiler pressure being kept at what could be regularly and comfortably sustained by the steady firing before mentioned, the engine working as a simple steam-engine under these circumstances. 2. To draw the fire completely, lighting again immediately with weighed coal; and, allowing a few pounds of pressure to accumulate (in compensation for the falling off of pressure occasioned by drawing the fire), to start immediately, with the ascertained proper load upon the break, and to run a continuous steady trial for a considerable time, taking indicator diagrams, noting the pressure and temperature inside the boiler, and generally determining the amount of work performed by a given quantity of fuel, the consumption of which would conclude the trial by bringing the engine to a standstill. 3. With the same break load and the conditions in all respects the same, to run a like trial with the engine in its combined form, noting the same points and again determining the amount of work performed by a given quantity of fuel. 4. To ascertain by friction diagrams the power consumed in working the air-pump.

The gross result obtained was that the engine consumed 140lb. of coal, when working with steam alone, in 196 minutes, and, when working with steam and air, in 234 minutes. During the former period the break, weighted with 120lb., made a total of 17,825 revolutions, or an average of 90·94 per minute, and during the latter a total of 22,815 revolutions, or an average of 97·5 per minute. With steam alone the gross horse-power of useful work done during the experiment amounted to 1,115·7; with steam and air, to 1,428·05. On the Warsop system the fuel not only lasted longer, but it also produced a greater effect during an equal period of time.

It was then thought desirable to institute a further series of experiments, under conditions which would obtain in ordinary daily work, and which may be thus stated:—

1. Maintaining the break load as before (120lb.), to fire evenly and steadily with weighed coal, and to drive at as uniform a rate as possible, doing the greatest possible amount of work with the fuel allowed, and discontinuing the experiment when, owing to the expenditure of fuel, the engine could no longer maintain her speed, and the steam pressure ran down; the engine to be working in the combined form, and care being taken to note the pressure and temperature in the boiler, the pressure in the air main, the amount of feed water supplied to the boiler, and the power developed. 2. Under like circumstances to run a corresponding trial with the air-pump disconnected, and to note the same facts as before.

The results are stated below, it being premised that the experiments were always commenced with a boiler pressure of 50lb.; and that, according to the practice of the Royal Agricultural Society, the fuel was deemed to be exhausted when 90 revolutions of the engine per minute could no longer be maintained.—Coal consumed, with steam and air, 120lb.; with steam only, 120lb.; duration of experiment, with steam and air, 153 minutes; with steam only, 112 minutes; number of revolutions of break, with steam and air, 15,433; with steam only, 10,500; average number of revolutions per minute, with steam and air, 100·8; with steam only, 93·75. Gross horse-power of useful work done during experiment, with steam and air, 965 9; with steam only, 657·22. Average horse-power of ditto, with steam and air, 6·31; with steam only, 5·86. Pounds of water consumed for each pound of coal burnt, with steam and air, 8·37; with steam only, 6·13.

In considering the value to be attached to these results, it was plain that the comparatively inferior performance of the engine left a larger margin for improvement than would be likely to exist in engines of the best finish and quality,

Great allowances must also, no doubt, be made for the want of economy in the boiler, as it is evident that a large quantity of heat was allowed to go up the chimney when the hot air pipes were not used. Still the saving is so great,—being about 47 per cent.—that a good case has undoubtedly been made out for further investigation.

We understand that a pair of engines have already been fitted and had several trials on a small iron screw steamer. She is named the *Fox*, and is intended for coasting purposes. She is schooner-rigged, carries 230 tons of dead weight, and was built by Messrs. Backhouse and Dixon, of Middlesbrough, for her owners, Messrs. Williams and Purvis. Her engines are by Messrs. Joy and Co., of Middlesbrough, and have a high-pressure boiler weighted to 60lb., and two cylinders of 15½in. diameter and 13in. stroke. The boiler is vertical with cylindrical furnace inside, and cross tubes from side to side, the uptake passing through the steam. The air-pump is 11in. in diameter, with 8in. stroke. The first trial trip of the *Fox* was made on the 13th of December last. She left Middlesbrough at 11 41 a.m., and went down the Tees under steam only. with a strong land wind blowing. She had neither ballast nor cargo, and rolled very much. She crossed the bar about 12 20, and got out to sea. The steam pressure was let down to 28lb., with only two inches of water in the gauge-glass, and a thin fire. At 12 40 the air was turned on, with the engine feed-pump at full work pumping through the feed-heater, and the donkey running slowly, pumping cold water into the boiler. At 12 58 the boiler pressure had gone up to 55lb., and from the continued feed the water in the glass stood at 19in. The engines were allowed full steam both at the stop valve and at the expansion lever. At 1 30 and thenceforward, the engines still working full speed, the boiler pressure stood at 60lb., and there was no priming. As an experiment, with this pressure and the screw making 112 revolutions, the air was shut off. Within two minutes water began to pass into the cylinders, and in three minutes the revolutions had fallen to 100. The air was again turned on, and in three minutes all priming had ceased, and the screw was again making 112 revolutions. From the heavy wind and the lightness of the vessel she was scarcely manageable, and the trip was brought to a premature close, having shown only that the engines worked well, and that the Warsop system prevented priming. A few days later she was taking cargo from Middlesbrough to Berwick, when, between Hartlepool and Shields, with the Warsop system in full operation, a pressure of 60lb., and the screw making 126 revolutions, the nut of a valve broke and disabled the air-pump for a time. It was immediately necessary to reduce the pressure on account of priming, and nothing above 30lb. and 90 revolutions of the screw could be maintained for the rest of the trip. The captain calculated that the stoppage of the air supply lost three hours' time in a passage that occupied eleven.

The next trip of the *Fox* was to Aberdeen, and on this, after five hours' steaming on the Warsop system, the air was turned off, and she was kept for five hours under steam alone. In the five hours under steam and air she ran by log 32½ miles, averaging 97½ revolutions per minute, and with an average boiler pressure of 50lb., and no priming. In the five hours under steam alone she ran by log 24½ miles, averaging only 71 revolutions per minute, with an average pressure of 35lb., and primed whenever the pressure reached 39. Under steam alone the consumption of coal was 345lb. per hour, and under steam and air it was 271lb. per hour; showing a saving of 27·3 per cent. of fuel, besides the increase in the rate of speed. It will be observed that the bad performance when under steam alone was principally owing to the extensive priming of the boiler which illustrates another peculiar advantage of using the Warsop system in overcoming the defect of a badly designed boiler, but which is scarcely of value for comparing the relative economy of the two systems. A better opportunity for a fair comparison will however be shortly obtained as the *Fox* has been chartered, by Messrs. Breslauer and Co., of Gracechurch-street, to run as a regular trader for the conveyance of goods between London and Exeter. There is a sister ship, the *Lynx*, belonging to the same owners, and precisely similar to the *Fox* in all respects, except that her engines have no air-pump. Arrangements have been made to compare the performances of the two vessels over a period of some months, noting their number of hours under steam, the total distance accomplished, and the total coal consumed by each.

PROPOSED TRAMWAYS AND RAILWAYS IN LONDON.

The following is a summary of an important report presented by Mr. Haywood, to the City Commissioners of Sewers, describing the numerous proposed undertakings in London; more especially as regards those that interfere with the City:—

Referring to the projected tramway schemes, four in number—namely, those called respectively the London Street, the East London, the North Metropolitan, and the North London tramways—Mr. Haywood describes the first-named as a scheme for the formation of tramways on the surface of many metropolitan thoroughfares, having several branch lines which will collect traffic from various suburban districts, the whole converging towards the City. They are briefly as follows:—1, a tramway commencing in Highgate Archway-road, to be carried along that road, the Holloway-road, Upper-street and High-street, Islington, thence along the City-road, Finsbury-square, and Finsbury-place, to the City boundary, near Ropemaker-street; 2, a tramway leaving the line just described in the Holloway-road, proceeding along the Camden-road, High-street, Camden-town, Hampstead-road, and Tottenham-court-road to Oxford-street; 3, a tramway commencing from the line in the Holloway-road at the Liverpool-road, proceeding along the Liverpool-road to High-street, Islington, where it again effects a junction with the first line; 4, a tramway commencing in the Edgware-road, over the London and North-Western Railway, proceeding along that road, Oxford-street, Regent-circus, joining the branch line in the Tottenham-court-road, thence along New Oxford-street and High Holborn to the City at Holborn-bars, a double line of tramway being then continued along Holborn and Charterhouse-street to Farringdon-road; 5, a tramway commencing in and carried along the Kentish-town-road, Chesnut-row, Great College-street, St. Pancras-road, Old St. Pancras-road, King's-cross-road, and Farringdon-road, entering the City at its northern boundary, at which spot it joins the line in Charterhouse-street, along Farringdon street (beneath the Holborn Viaduct), New Bridge-street, Blackfriars-bridge, Blackfriars-road, St. George's-circus, and Westminster-bridge-road, terminating at Belvedere-road, near Westminster-bridge; 6, a double tramway leaving the line last described in New Bridge-street, and carried along the centre of Queen Victoria-street to a spot near the Mansion-house; 7, a tramway starting from the line in the City-road, proceeding along Goswell-road and street, entering the City at Fann-street, thence continuing as a double line along Aldersgate-street to Carthusian-street, then by a single line to Hare-court, and thence by a double line along Aldersgate-street and St. Martin's-le-Grand to Newgate-street; 8, other tramways, leaving the line in Farringdon-road at Clerkenwell-green, proceeding along Aylesbury-street, St. John's-street, Compton-street, Northampton-street, and Percival-street, forming junctions with the line in Goswell-street; and, 9, a tramway in the Caledonian-road, commencing at the spot where the Great Northern Railway crosses it, proceeding along the Caledonian, Roman, and Offord roads to a junction with the Liverpool-road tramway. Each line of tramway is to consist of two rails, laid to a 4ft. 8½in. gauge, the top of the rails to be at the same level as the surface of the street. The cab-stands and public urinals are left unaltered, the tramways being taken round them. The company is to be bound not to open or break up any greater length of street at a time than 100 yards, excepting where streets exceed a quarter of a mile in length, and in such cases an interval of at least a quarter of a mile is to be kept between any two openings. The company is, at its own expense, to pave and keep paved in good condition and repair so much of any street where a tramway is laid as lies between the rails of the tramway (where two tramways are laid in any street not more than 4ft. from each other), the portion of the street between the tramways, and in every case so much of the street as extends 18in. beyond the rails of and on each side of any tramway. In other words, where there is one line, the paving for about 8ft. in width in the centre of the street, and where there is a double line, the inner rails of which are not more than 4ft. from each other, the paving for a width of 17ft. in the centre of the street will be paved and maintained by the company. The materials and mode of paving in the City of London are to be executed according to directions to be given by the Commission of Sewers. The powers of the Commission to alter the public ways are reserved, and also those relating to the sewers, drains, gullies, subways, &c. Before executing any works in connexion with the sewers, &c., the Commissioners are to give the company 24 hours' notice, and they are not to be liable for compensation for injury to the tramway by reason of such works or for loss of traffic occasioned thereby. The company is restricted to the use of animal power for traction. The right to use the tramway is reserved exclusively to the company until the expiration of three years from the opening for public traffic, when the Board of Trade is to have power to grant licences to other parties to use the tramways under certain conditions. The total prescribed for passengers is 1d. per mile, but the company may charge 3d. for any distance less than three miles for a period of three years from the opening for public traffic, at the expiration of which time the Board of Trade is, under certain conditions, to have power to compel the company to charge 2d. only for distances not exceeding two miles. Two carriages at least are to run each way daily for artisans, mechanics, and labourers at the rate of one halfpenny per mile, with no fare less than 1d. Penalties may be enforced against persons using vehicles with wheels specially adapted to run on the tramways, but nothing in the Act is to affect the right of the public to pass along, on, or across them with carriages having ordinary wheels. All differences between local authorities and the company in respect of their works, whether paving sewers, or otherwise, are to be settled by an engineer appointed by the Board of Trade.

The North Metropolitan Company propose to form tramways on partly single and partly double lines, starting from and proceeding along Highgate Archway-road, Holloway-road, Upper-street, High-street, Islington, the City-road, Finsbury-square and Place, entering the City near to Ropemaker-street, thence by a double line of tramway along Moorgate-street, and terminating near to Lothbury; also a tramway starting at Liverpool-road, and proceeding to a junction with the first line at High-street, Islington, near to White Lion-street; and, thirdly, a tramway commencing in the Seven Sisters'-road, near the Stroud Green-lane, and carried along that road, Park-road, Camden-road, High-street, Camden-town, Hampstead-road, and Tottenham-court-road, terminating near to Oxford-street. Some of these lines are to follow the same route as those proposed by the London Street Tramways Company. The company also proposes extensions eastward of lines now in process of formation under the North Metropolis Tramways Act of 1869; they having power to construct, under that Act, lines from Whitechapel Church to Stratford; which lines they now propose extending —firstly, along the Romford-road to Wood Grange-road; and, secondly, along Stratford-grove, Leytonstone-road, and Union-road to Low Leyton. They also propose a double line of tramway effecting a junction with the above lines at Stratford Church, and proceeding along Stratford-broadway and High-street, and High-street, Bow, form a junction with authorized lines near to Bow Church. This double line is in substitution of and follows the same route as other lines authorized by the Company's Act of 1869. Also to extend their authorised line from Whitechapel Church, westwards, along Whitechapel High-street, terminating at Aldgate High-street, near the Minories. This tramway is to be formed with two rails, having a gauge of 5ft. 3in. from the outer edge of each rail; the upper surface of the rails is to be on a level with the surface of the street. The right of Local Boards are reserved, and the tolls are about the same as those of the other companies. The project of the East London Tramway Company has been withdrawn very lately. It was for a double line of tramway commencing in the Commercial-road by Salamon's-lane, proceeding along Commercial-road east to Whitechapel High-street, thence to the City, which it was to enter at Somerset-street, proceeding along Aldgate High-street, Minories, Little Tower-hill, and by way of Postern-row, and George-street (one line each) to a termination in Great Tower-hill by Trinity-square. The whole of the works contemplated by the North London Company stop outside the City boundary, the nearest point to the City being in Farringdon-road, north of Charles-street. The rail being now laid along the Whitechapel and Bow Road is a flat bar of iron about 4in. wide and 1¾in. deep, the upper surface having a groove about 1in. wide and ⅞in. deep, on which projecting flanges on the wheels of the carriages will run; the rails are secured to wooden sleepers 4in. wide and 6in. deep, laid on a concrete foundation. The gauge is the same as the narrow gauge of the railways in this country—viz., 4ft. 8½in., the rails being retained at that width by iron chairs and tie rods stretching from rail to rail at intervals of about 4ft. 6in. The paving between and outside the rails is at the same level as the top of the rail. The groove is about one inch from the inner side, and is corrugated. The outer space from the groove, which is 2in. wide, is smooth for the tire of the wheel to run upon.

Mr. Haywood next proceeds to say that the applications to Parliament for power to make tramways in the metropolis upon the extensive scale now projected lead to the belief that a great change may shortly be held in the mode of conducting the transit of public vehicles in London, and, as the value of most of the lines would largely depend on their being allowed to enter the City, the subject is one requiring the gravest consideration. The question is, indeed, one so largely affecting the convenience of the metropolitan population, which depends in so great a degree on facilities for going to and from the City of London, that it must be considered in reference to the wants of that population, and not alone to the convenience of those whose dwellings are within the City limits. Street tramways, generally understood, are railways laid at the street surface for facilitating the traction of omnibuses, and the time may come when they will be equally used for the conveyance of merchandise. At present, however, the conveyance of human beings is the sole purpose for which they are used generally and are intended to be used in the City of London. They exist to a large extent in New York, Chicago, St. Louis, Philadelphia, and, indeed, every large town in the United States. In those towns the cabs and other vehicles are few in number and comparatively little used. The tramways are almost exclusively used by all classes. In Toronto, Montreal, and other towns in Canada there are similar street railways, and they also exist in Valparaiso, Nova Scotia, St. Petersburg, Vienna, Berlin, Brussels, Copenhagen, Hamburg, and Geneva. There is a line from Paris to St. Cloud and Versailles, which has existed some years; also a line at Birkenhead, and a short length at Manchester. A considerable length is laid at Liverpool, and extensions are now being made, and there is a similar tramway in the Potteries. In 1861 permission was granted by the Local Boards to lay down lines from the Marble Arch to Bayswater, from Kennington-gate to Westminster-bridge, and from Westminster Abbey to Victoria station. These were some time in existence, but owing to objections made to the form of rail, which was alleged to be dangerous and inconvenient to the general traffic, they were taken up. Nothing was done from that time until the Session of Parliament 1867-68, when bills were deposited for the construction of tramways in various parts of the metropolis. None of those, however, became law. Last year three Acts were obtained for the construction of tramways, one being the North Metropolitan Tramways Act, authorising their construction in the Whitechapel and Bow-roads to the east of the City of London; another the Metropolitan Street Tramways Act, authorising their construction in the Brixton, Kennington, and Clapham-roads; and the third, the Pimlico, Peckham, and Greenwich Act, authorizing a tramway from the Vauxhall station of the South Western Railway to Greenwich. None of those tramways have yet been completed, but some of the lines will be ready for traffic early in the spring, and perhaps even before the various bills now before Parliament are referred to a committee. At present in the metropolis experience is confined to the working of the tramways in 1861. It is stated that the form of rail now proposed to be adopted is so different to that employed in 1861 that the objections on that score made against tramways are greatly, if not entirely, obviated. The completed line at Liverpool runs from one of the suburbs into the most important part of the City. Personally he (Mr. Haywood) had travelled on the street tramways in America, Canada, and in many of the European cities referred to, and those who have once ridden on them will, he believed, concur with him in bearing testimony to the great comfort and convenience they afford, although in none of those cities have they reached their full development, for there is no reason why they should not be made suitable to the wants and means of different classes of society, which, he believed, had not been attempted. It is somewhat surprising that so long a period should have elapsed before street tramways have had at least a fair trial in London, for the greater the population the greater their convenience will in most respects be. On the other hand, the narrowness of some of the important thoroughfares, the occupation of the soil by gas and water companies, and the large traffic offer difficulties in the way of their construction and maintenance which do not exist to a similar extent in other Cities. Great difficulties have, however, been overcome in the construction of railway and other engineering works, and we should not have had the benefit arising from them had every obstacle in their way, or had every objection which could be raised against them, been sufficient to prevent their construction. Objections can undoubtedly be raised against street tramways, but they may, perhaps, be vanquished. The benefits and disadvantages likely to arise from street tramways would, therefore, have to be carefully weighed by the Commission before it could arrive at a safe conclusion and determine whether it should use its influence in opposition to their construction within the City, or should make such arrangements as may protect the interest of the citizens, and, at the same time, make them as little onerous as possible to the projectors. Special consideration will be needed as to how far a company should be allowed to establish what will be by many considered a monopoly of portions of the public highways. The objections on this point have, however, been already raised before Parliamentary Committees, but have not been thought in respect of the Metropolitan and the Liverpool Acts already passed to outweigh the advantages which the schemes possess; but if very large benefits are likely to accrue from tramways as well as large profits to the companies, and there are objections to permitting private companies to construct them, it is a question whether Highway Boards should not themselves form such tramways out of the public rates, and this is an essential questions at the threshold of the whole inquiry.

With reference to the railway projects before Parliament affecting the City, the first is that of the Great Eastern Company. In 1864 and 1865 that company obtained Acts to construct a line of high level railway, commencing on the northern side of Liverpool-street, near to Broad-street-buildings, and proceeding thence in a northerly direction, crossing Half Moon-street, Sun-street, Skinner-street, and Primrose-street, and effecting a junction with the main line at Tap-street, Bethnal-green, near the Brick-lane Goods Station. It was to have been constructed at heights above the street level varying from 16ft. 6in. to 19ft., the streets being crossed by bridges; the area scheduled within the City was $10\frac{3}{4}$ acres, and the effect of the scheme would practically have been to transfer the Shoreditch Terminus to Liverpool-street. In 1865 the East London Company also obtained powers to construct a railway, following within the City the same line as that of the Great Eastern, just described; but the level was to have been 16ft. below the surface at Liverpool-street. In effect, the two schemes formed a double line of railway, the one subterranean, passing under the streets, the other a viaduct passing over them. It is proposed by the present bill to abandon the high-level scheme, and to construct a railway at about 17ft. 6in. below the street surfaces, forming by a curved branch at Liverpool-street a junction with the Metropolitan Railway (Tower-hill Extension) authorised in 1864, the levels of which will have to be altered to admit of the junction. The company seeks for extension of time for the powers of the Act of 1864 to the year 1873, and also power to take additional property in the vicinity of Liverpool-street, New Broad-street, Sun-street, and Primrose-street—the total area being about $2\frac{3}{4}$ acres. Powers are also sought to construct various branch railways, or to make alterations in others already authorised in Bethnal-green, Edmonton, Hackney, Walthamstow, and other places, the object being to collect Metropolitan traffic. Angel-place and Angel-alley, in the City, are to be stopped up.

The Metropolitan Railway Company apply to Parliament for power to abandon so much of the railway authorised by their Act of 1864 as lies between Bishopsgate-street and Tower-hill. It may be thus assumed that the company propose to extend the railway to Bishopsgate-street, but no further. The question as to powers which may exist of compelling the company to complete their original plan requires immediate investigation.

The Metropolitan District Railway Company seek power to form a line of railway to the Mansion House, beginning by a junction with the authorized line west of Tower-hill, and then to be carried beneath and along the centre of Queen Victoria-street towards the Mansion House, stopping at about 130ft. from the north-western angle of that building. The station is to be in Queen Victoria-street, next to Bucklersbury, upon a portion of the vacant ground at that spot, and about 270ft. from the same angle of the Mansion House, and it is proposed to construct a subway for foot traffic from the station, passing beneath Mansion House-street to the open space in front of the Royal Exchange, near to the Wellington statue, so that passengers can go to the railway by that subway. It is anticipated that by this arrangement passengers coming by way of Princes'-street, Threadneedle-street, Cornhill, and Lombard-street, will enter the station by the Exchange subway, and those from King William-street, the Poultry, Cannon-street, and Walbrook by Queen Victoria-street. The level of the rails will vary in depth below the surface of the new street from 27ft. to 32ft. A total area of about $7\frac{1}{2}$ acres of property is scheduled, including a large portion of vacant land belonging to the Board of Works. The whole of Queen Victoria-street is now, also, under the control of the Board, and, although used by the public, has not yet been given up as public way. Taking the statements made in reference to it to be correct, it appears that funds are not forthcoming for the extension of the railway to Tower-hill, and it is, therefore, to be stopped in or near to Queen-street, and as the Metropolitan Railway Company also desires to abandon its Extension beyond Bishopsgate-street, it looks as if the Inner Circle Railway was not to be completed. Assuming that to be the case, the question will be whether the convenience to the public would balance any inconvenience resulting from a station being formed near to the Mansion House, a subject requiring further detail and careful inquiry.

By the East and West Metropolitan Junction and Mansion House Railway scheme it is proposed to form, first, a railway by a junction with the authorised line of the Metropolitan Railway (Tower-hill Extension), now proposed to be abandoned, near to Meeting-house-yard, proceeding thence by a curved line in a south-easterly direction to Whitechapel High-street, continuing along that street, Whitechapel-road, crossing beneath the authorised East London Railway, the Mile-end and Bow-roads, to the North London Railway at Bow. It does not make a junction with that railway but it is evidently intended to have an interchange station at that spot; also to form a second line of railway commencing by a junction with the Metropolitan District Railway near to Bread-street-hill, proceeding thence beneath Queen Victoria-street, Cannon-street, crossing King William-street north of the statue, and Gracechurch-street at its junction with Eastcheap; then curving to the north-east beneath property to the northern corner of Mincing-lane, passing beneath Philpot and Rood-lanes, it enters Fenchurch-street, and is to be carried beneath it to Aldgate, and along Aldgate High-street (beneath the Metropolitan Railway, Tower-hill Extension, now proposed to be abandoned) to a junction with the line first described at Whitechapel High-street near to Lemau-street. It is to be subterranean, its level varying from 18ft. to 42ft. beneath the public ways, the surfaces of which are to be unaltered in level in all cases. The area of property scheduled within the City is about $7\frac{1}{4}$ acres in all.

The next project is one for the formation of a subway for passenger traffic between the City and Southwark. It is to commence at the corner of Martin's-lane, in the City of London, run beneath the public ways of Arthur-street West (crossing Upper Thames-street), beneath Swan-lane and then under the river bed to a point close to the south-western steps of London Bridge. It is then to be carried beneath the public way of Wellington-street, Southwark, to a terminus at the corner of Blackman-street and Great Dover-street, in the parish of Newington. The floor of the subway at Arthur-street West will be about 77ft. below the street surface. On the northern bank of the Thames it is to be 55ft., and on the southern bank 70ft. At its terminus in Blackman-street it will be 62ft. beneath the surface. The total height of the subway will be about 20ft. It is to be formed of cast-iron of similar character, and be executed in a similar manner, to the one just completed beneath the river at Tower-hill, and is intended to convey passengers by omnibus, which will be moved partly by gravitation and partly by small stationary engines at each end. The journey through the subway will occupy but four or five minutes, and the fares are to be extremely low. The subway, if constructed would, there is no doubt, take much traffic which at present goes by way of Wellington-street, High-street, and London Bridge, and would, therefore, relieve those thoroughfares. Only one house in the City is to be taken down; the total area in the City scheduled is fourteen perches only.

The total area for all the railway projects in the City is about $18\frac{3}{4}$ acres, and the length of street required there for the tramways two miles five furlongs. Mr. Haywood concludes by stating that it will be necessary for the Commissioners to obtain more information on most of the projects than they now possess, and that it will be needful that they should dissent from the whole of the works so as to obtain a *locus standi* before the Committees of the Houses of Parliament, to which the Bills will probably be referred. The Commissioners, at their last meeting, adopted the last suggestion of their engineer, and ordered his report to be printed and circulated among the members of the Corporation. They also approved the general principles of the tramway schemes, but left the Bridge-house Estates Committee to watch them in their progress through Parliament.

KENNEDY'S ENDLESS CHAIN SAW.

We are indebted to the *American Artizan* for the following description of this curious invention:—

The great expense of circular saws large enough for sawing heavy logs of great size, and the consequent loss incurred in the event of any injury thereto, renders it highly desirable that some substitute, possessing the same advantages of continuous motion in one direction, should be provided. The invention herewith illustrated is designed to furnish such a substitute,

Fig. 1.

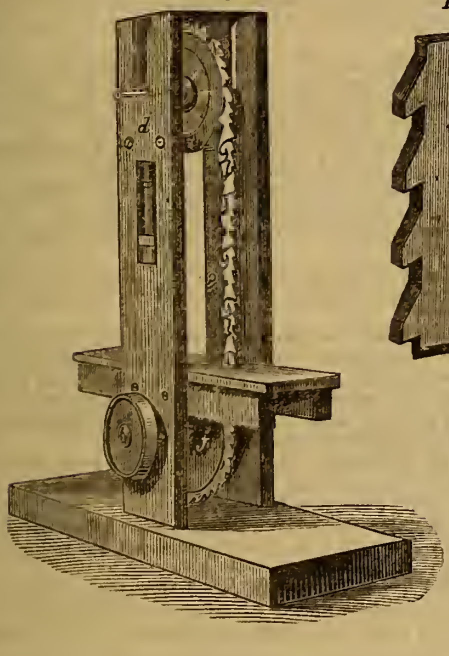


Fig. 2.

and consists in an endless chain saw, the links or sections of which are made, as it were, of S shape, as shown in the enlarged Fig. 2, so that they can be hooked to and connected with one another to constitute the saw, without the use of pivots to connect the links. One of the hooked ends, it should be mentioned, of each link is so formed that, when hooked upon the adjacent end of the link next to it, it will fit into a narrow recess formed in the latter, so that any latteral displacement is provided against. The saw, constituted by the connection of any desired number of these links or sections—each formed with any suitable number of teeth—is passed in a vertical plane over two grooved pulleys, the upper one of which has vertically adjustable bearings, by which it may be adjusted to regulate the tension of the saw, while the lower one has upon it the pulley or band-wheel by which the saw is driven.

Among other advantages claimed for this improved saw is that it can easily be extended from cutting two feet timber to six feet timber, by raising the upper wheel, and adding the requisite number of sections, the thickness of the saw remaining the same; to do which with a circular saw would require one (if it could be made) of a diameter equal to the length of an ordinary log, at a cost of hundreds of dollars, and a thickness of not less than half an inch. Also, that it acts in a straight line, and is at the same time capable of being adjusted to any angle of the wood, as in the case of the hand saw. The manner in which a circular saw enters the wood is at first dead against the grain, and from that it gradually works its way out in a quarter circle; this is the very hardest of the work, and consequently requires the most power. This is overcome by the endless chain saw. Also, the limited extent of injury in case of accident. As the destruction or damage of two or three teeth only involves the section of which they are a part, that section can be replaced by a new one in a few minutes, without any injury to the rest of the saw. If the obstruction be of a character to destroy a circular saw or tear out every adjustable tooth, the section of this saw encountering it would break, and the saw stop; the broken section being the only loss.

THE UTILISATION OF TOWN SEWAGE.—The Cardiff Local Board of Health, at their meeting, subscribed £21 to the British Association for furthering the best means of utilising town sewage, the general opinion being that the town would derive great benefit from it.

PATENT LAW.

THE BOVILL LITIGATION.

(*Continued from page* 46.)

We have given the Vice-Chancellor's observations upon the evidence of Mr. Muir, whom he had not seen, and who had not been cross-examined nor contradicted in regard to that evidence.

In contrast with those observations, we now quote from the shorthand notes of the fifth day's proceedings on the second trial of "BOVILL *v.* GOODIER." Mr. Muir was giving his evidence before the jury, and was cross-examined by Mr. Garth, Q.C., on behalf of Mr. Bovill.

Mr. Garth: Did you have any communication with Mr. Bovill with reference to taking a licence from him?—A. Yes.

Q. Both verbally and by correspondence?—A. Not by correspondence, but verbally.

Q. When was it you saw Mr. Bovill?—A. In 1851. Mr. Don pressed me very much to come up and see the arrangement.

Q. Did you discuss with Mr. Bovill the terms upon which he was to grant you a licence, or upon which he would grant you a licence?—A. I discussed with Mr. Bovill in my interview with him in 1851. After I had seen his arrangement in operation I discussed with him the matter of getting permission from him to drive the air through the upper stone with a closed eye. Any discussion I ever had with Mr. Don or Mr. Bovill on this matter was entirely in reference to the arrangement that he had of the blast, not to the exhaust at all.

Q. That is a very long answer. Did you not discuss with him the terms on which he was to grant you a licence?

Mr. Justice Byles: A licence for what? For a portion of the invention he says relating to the stones and the blast, but having nothing to do with the exhaust.

Mr. Garth: You were examined on the former occasion in this case?—A. Yes.

Q. Did you, when you were examined before, ever say a word about the licence which you proposed to take from him, as you have just now told us?—A. No.

Q. Why not?—Because I was not aware of the exact nature. In fact, I believe when I was last in this witness-box I positively asserted that I never had any communication with Mr. Don by letter or paper of any kind, but I am glad to say that to clear up the matter I have since found documents which—

Q. You have since found letters from Mr. Don, you say?—A. A letter from Mr. Don, and also a memorandum from Mr. Bovill, which I received from him.

Q. That is the very thing. I am glad you have found it. Have you got it there?—A. Yes, I have it here.

Q. Did not Mr. Bovill write down the memorandum in your presence, and hand it to you as the terms upon which he was to give you a licence?—A. Mr. Bovill was very anxious to get me to take a licence from him of his exhaust and blast arrangements. I said to him, after seeing the arrangements in operation at Deptford Mills, that I saw no difference, and you will find that in my previous evidence.

Q. Go on.—A. And by that I mean that I saw no difference in the result. He arrived at his result in one way, I arrived at my result in another way; but the results were quite the same. I told him I had no necessity to come to him for the exhaust, as I had it already.

Mr. Justice Byles: I do not think it is necessary at all, either for your justification, or for any other purpose, to go through this in detail. Answer the question as briefly as you can.

Mr. Grove: The last answer may be of importance. He says he and Mr. Bovill arrived at the result one in one way, and the other in another.

Mr. Fullarton: He added to that answer which Mr. Grove has just asked your lordship to take down, "I told him I had no reason to trouble him for the use of his exhaust."

Mr. Justice Byles: Really we get into quite unnecessary confusion about this. He began by very candidly saying there was a mistake in my former examination, and I am now in a position to correct it. That happens to every man.

Mr. Garth: In your former examination, did you say anything about what you have told us now with regard to these memoranda?—You had forgotten about the memorandum, had you not?—A. Yes. You will perhaps read the examination before putting any questions to me. I shall be very glad to answer.

Mr. Garth: I think that is quite right.

Mr. Justice Byles: Which page is it?

Mr. Garth: Still the same page—205 of the printed report of the former trial.

Mr. Webster: He says, "I never wrote to Mr. Bovill that I am aware of."

Mr. Justice Byles: You had better read it—we are wasting time.

Mr. Garth: My learned friend, Mr. Grove, asked you this: "Perhaps you will answer my question as to whether you had not a discussion with Mr. Bovill as to a licence, aud whether the terms were not discussed betweeu you? That is my question, and it seems to me to be not a very difficult one to answer?—A. No. Q. You had not?—A. No. Q. I ask you this. Not only were not the terms discussed, hut were they not written dowu by Mr. Bovill at an interview that you had with him, and did you not take them away with you?—A. I am not aware of the fact. Q. Will you undertake to say whether it was so or not?—A. I am not aware of the fact. Q. Am I to take that answer, 'I am not aware of the fact,' that you do not know whether it was so or not?—A. I may have had a general conversation with Mr. Bovill ahout his patent?—Q. My question was uot general?—A. I am quite willing. Mr. Justice Willes: Attend to the questiou. Did not Mr. Bovill write down the terms in writing, and did you not take away that writing with you."

Mr. Justice Byles: And now read his answer.

Mr. Garth: The answer is—"It is quite possible I may have done so. I do not remember at the present moment."

Mr. Justice Byles: He did not say he did, not, only tbat he did not remember it at tbe moment. He began candidly, by saying, 'I have fallen iuto a mistake—there is the memorandum."

Mr. Garth: How have you come to recollect now all the particulars of the conversation which you did not recollect before as to the time of the memorandum was given?—A. I am very happy to give you the reason.

Mr. Justice Byles: You can do it, sir, for your own justification.—A. Most unfortunately for myself and for my business reputation I made some mistake in dates with reference to this matter, and also with reference to the conversation with Mr. Bovill; and when I got back to Glasgow, I made a most searching examination for every scrap of paper that I could find ahout the place. I have now got all my books, and have examined all my letters in regard to this matter and everything appertaining to it, and I think I am certainly now in a position to answer every question you can possihly put to me in reference to this matter. That point you speak of about tbe conversation with Mr. Don and Mr. Bovill—

Q. The conversation with Mr. Bovill is what I am drawing your attention to.—A. The whole history is before me in this letter.

Mr. Justice Byles: Do you mean to impute to this gentleman an intentional misrepresentatiou?

Mr. Garth: Oh, no, my lord; simply this—that on the former occasion his memory was very defective.

Mr. Justice Byles: If you mean to impute that, of course I shall not stop you; if you do not mean that, what can you have more than you have got. He says I made a mistake, and I have searched through all my papers and I have come here to correct it.

The Witness: This is the letter; it is opeu to be read, and it will tell you tbe whole thing.

Mr. Garth: Be kind enongh to give me, first of all, this memorandum, which you say you have got.—A. There it is [producing it]. It is not even addressed to me—it is a simple memorandum.

Q. It was given to yourself by Mr. Bovill?—A. Certainly; I rememher the circumstance.

Mr. Justice Byles: As to this sort of cross-examination, you will judge whether it endangers the defendant's case or advances it.

Mr. Gartb: I propose to put this in, my lord.

Mr. Justice Byles: Oh, no. My Brother Willes very bitterly complained of it as disadvantageous to the defendant. I said so yesterday, and I repeat it to-day.

Mr. Garth: Upon my word, my lord, I do not kuow that we could do other than we have done.

Mr. Justice Byles: I do not know what impression this gentleman has made on the jury, but anything more candid I never beard.

Mr. Grove: There never has been any question as to his credibility. It is an entire misrepresentation.

Mr. Justice Byles: He is now here, and ready to state all about it.

Mr. Grove: My lord, as I am iuvolved, in some respect, in these matters, will you allow me to state this. Mr. Muir, on tbe last trial, was rather sensitive, and considered that some questious put to him went to affect his credit. I emphaticaily disclaimed it, but I thought that the gentleman's memory was very infirm. I said so in so many words at the last trial, and I say so still.

Mr. Justice Byles: You meant it then, and you mean it now.

Mr. Grove: I tested him closely as to dates, and my case then and now is tbat he made very considerable mistakes as to dates. I did uot say he said auything purposely wrong. I most carefully, in my address to the jury, gnarded myself upon that.

Mr. Justice Byles: You need not repeat that, Mr. Grove. Let us go on to something material.

Mr. Garth: You had, previously to this conversation with Mr. Bovill, seen Messrs. White and Ponsford's Mill at work. You had seen his system and apparatus at work at the City Mills?—A. Not at the City Mills. The City Mills were not started then; it was at Deptford. Mr. Bovill did not go with me to Shadwell. Mr. Bovill was at Deptford—the Government Mills at Deptford.

Mr. Webster: Do you put that memorandum in?—Mr. Grove: Yes.

Mr. Justice Byles: Let it he read; but let me read it before it is read, if you please. It may be taken as read, perhaps, because it is hardly intelligible. It shall be read if it is desired.

Mr. Garth: Did you see Mr. White, who was one of tbe owners in the City Mills, after you had seen the Mills at Shadwell?—A. Yes.

Q. Did you tell Mr. White tbat the apparatus which you had seen at Shadwell was a great improvement in milliug?—A. At Deptford.

Q. Did you tell him so?—A. I did.

Q. That was Mr. Bovill's apparatus?—A. Yes; I admired it very much.

Q. How long after you discontinued the use of this apparatus did you put up another apparatus at your mills?—A. I do not quite comprehend what you mean.

Q. You tell us tbat you discontiuued the use of this apparatus iu 1852. I ask you whether it had not been discontinued in 1851. I waut to know after you had discontinued that apparatus, when you put up another?—A. There need he no doubt upon tbe date when I discontinued it.

Mr. Justice Byles: You need uot go back to that; pray do not trouble yourself, but answer the question.—A. I have it in my letters.

Mr. Garth: You may answer the question in any way on reference to document.—A. Do you meau an apparatus in connection with this?

Q. I want to know how soon after you discontinued tbe one apparatus you put up another?

Mr. Justice Byles: Did you put up any other?—A. Yes. We put up in August, 1853, silk-dressing machines; and in connection with those silk dressing machines—

Mr. Justice Byles: Now, wait: pray do not go on with what is immaterial. You have answered the question, "We put up silk dressing macbines."

Mr. Garth: My learned friend, Mr. Grove, wishes me to ask you again tbis question—Was not the apparatus completely taken to pieces when Mr. Don was there, and did not you show him the pieces in May, 1851?—A. I showed him the various parts of tbe apparatus.

Q. Were they not all detached? It was not at work?—A. I have already answered you that question most distinctly—that it was at work then. I bave my letters aud hooks here to show.

Re-examined by Mr. Wehster: Q. When was this memorandum that has heen produced given to you.—A. It was given to me wben I was in London iu 1851. I was anxious, most anxious.

Q. That is quite sufficient: it was given you in May 1851. I believe you are aware that Mr. Bovill's Scotch patent for this blast was not taken out until 1863.—A. I was very much astonished to find that afterwards.

Q. Do you kuow now that with regard to this whioh is called the superadded blast and exhaust, that was not the subject of a Scotch patent till the 28th of May 1843.—A. I am now aware of the fact.

Q. You know tbat fact.—A. Yes.

Q. In 1851 had Mr. Bovill any patent excepting his Scotch patent of 1846.—A. Not tbat I am aware of.

Mr. Justice Byles: Your last answer is not quite correct, is it? Tbere is the patent of 1849 which we are now discussiug.

Mr. Webster: The other patent is in Scotland my lord. I helieve you are aware that Mr. Bovill had two pateuts, an English patent of 1846, and a Scotch patent of 1846?—A. Yes.

Q. But the English patent of 1846 was for tbe super-added hlast without the exhaust.

Mr. Justice Byles: Very well.

Mr. Webster: And that be bad no patent in Scotland for the blast and exhaust combined, until the 28th of May 1853.—A. I believe that is so.

Q. Now Mr. Gordon's invention was for introduciug the air, so as to keep the meal from the eye to the circumference of the stone cooler in grinding, was it not.—A. Yes.

Q. That is what we have now called a super-added blast.—A. Yes.

Q. You told us the effect of that was to fill the meal with stive. A. To fill the meal with stive.

Mr. Webster: That is all I ask.

Mr. Grove: Will your lordship permit me to do this for my own justification. Your lordship has referred to me two or three times with reference to this gentleman, and I do ask to be allowed to say this for myself—this is what I stated to the jury in addressing them upon his evidence: "We have an instance of a gentleman, honestly I believe—I make no mention against him of dishonesty in this respect—houestly pledging his oath to a matter which was utterly false iu fact; not false to his intention, as he swore it, and that is Mr. Muir. I make no accusation of any real intention, hut Mr. Muir positively swore in this witness-box that he had discoutinued the blast, but uot discontinued the exhaust, and he was as firm and positive upon it as any man ever was; hut he was mistaken, and he honestly admitted that he was mistaken." Now, I ask your lordship, whether that is not exactly what I stated—that I did not make any reflection upon this geutleman's character?

Mr. Justice Byles: You did him justice upon the former occasion, and do so now; and I do him the justice on the present occasion to say there is no reflection whatever upon him.

The Witness: I am much obliged to your lordship for the remark.

Mr. Grove: But your lordship will permit me to say I wish to do justice to my clients. I only said on the former trial that he was thoroughly mistaken as to dates. I did not like the sort of suspicion that seemed to be thrown upon me that I reflected upon his credit.

It is impossible to imagine anything more decisive for the condemnation of the mode of procedure in Chancery than this remarkable approval of Mr. Muir's evidence when given *viva voce* before a jury, and the flippant rejection of it by the Court of Chancery, and we commend it strongly to the attention of those who may be disposed to think slightly of the advantage of trial by jury. We must proceed with our quotation from the judgment:—

"Then the Isleworth case was repeated as it was before, and I only refer to it by a word or two before I come to the case of infringement. There is nothing new in it beyond the fact that Mr. Podger has taken a licence which he had not done on the former occasion.

"Then there is Westrup's case. It is true that Westrup speaks positively of having set up that which would amount to an anticipation of the plaintiff's patent some time in the year 1847, but his mills were unfortunately burnt down in July, 1848. It is a remarkable feature in this case that not a single thing is in *esse* anywhere which can be found to have existed anterior to the plaintiff's patent. In the Isleworth case I have the same evidence here that I had before, something of the kind was admitted, as to which I must say a little more when I come to speak of the infringement. That does not seem to have been very successful. The moment after the plaintiff's patent comes out a different apparatus is set up at Isleworth, which is in accordance with the plaintiff's patent, and then a different state of things arises. As regards Westrup's case, there is the curious fact the mill is burnt down. We have not got in this case a gentleman named Crampton, who gave evidence in a former case, and it is not proper that I should allude to what Mr. Crampton said in that case, but there is this fact brought out on the cross-examination of Westrup. The plaintiff and Mr. Bramwell (who was acting in some way as agent for the plaintiff then) did visit Westrup's Mills continually; this was about the time that the apparatus was alleged to have been put up in 1847; that Mr. White and Mr. Ponsford did visit him; that after the patent, Westrup was perfectly well aware that White and Ponsford were in treaty with the plaintiff Bovill (that is what he says in his cross-examination) for the use of his patent, not one syllable did Westrup then say about it as being all moonshine, that the patent was not worth a farthing, that the thing had all been done in 1847, he, knowing that these gentlemen were making inquiries in respect to this patent, never did it occur to Mr. Westrup to mention that an apparatus had been put up which had been successful for a few months before his mill was burnt down; never did it occur to him to set it up again, and never did it occur to him to recommend any one else to set it up. Well, really what a shadowy sort of case it comes to when I look at the cases of Wren and Muir. When I see the sort of case attempted to be set up by them, this alleged existence for a a short period during which Westrup says this machinery was set up in his mill, although in the mean time he had frequently seen persons who were in very serious and large concerns, such as White and Ponsford's, treating with the plaintiff as regards the patent, not one single syllable did he say about it, and nothing is heard about it until after this litigation arises. Well, if a man's patent could be overturned by evidence of this description, it does appear to me it would be absolutely useless for anybody ever to attempt to take out letters patent for any invention whatsoever."

Our only comment upon this is, that Messrs. Crampton, White, and Ponsford were shown to have visited Westrup's Mill, which was burnt down in 1848, with the view of seeing Bovill's patent of 1849 at work; that Westrup was working that blast successfully and without inconvenience, because he was applying the exhaust very much in the manner shown in Bovill's patent of 1846 for the purpose of getting rid of the stive; but the evidence is disbelieved, because Westrup did not in 1848 tell White and Ponsford that Bovill's patent of 1849 was all moonshine! The judgment continues:—

"Now, as regards some of the other cases which have been mentioned in this evidence, I think we have none of the old cases except the Houghton Mill: this is the only one I have not adverted to. It has not been proved. In the case of the Houghton Mill, they had holes in the mill-stone case. I think it is mentioned that a great many more have been cut, although before we knew of the existence of a considerable number of holes. We have the additional evidence that Mr. Potto Brown, who had not taken a licence before, has now taken a licence, which Mr. James read. What has been stated shows that the things he had been using would not come within the plaintiff's patent, and that seems to have been his view, as stated by him in the Privy Council, not that the patent was at all bad, but that the things he had used were of a totally different character; not on account of their being used by inflation without suction, but that they were of a totally different contrivance. By those holes cut in the box he got a contrivance by which the plenum should be exactly exhausted, and no blast occasioned."

The incidents connected with Mr. Brown's Mill at Houghton are so odd that we must state them. Mr. Brown and his son, Mr. Bateman Brown, gave evidence in this suit of the use of a fan applied to exhaust the stive from the mill-stone cases in Houghton Mill, and to blow it into a stive room, continuously since 1846. The only evidence in contradiction was that the stive was much more successfully exhausted in 1866 than it was before 1849. The holes referred to were made in the hoop of the mill-stone case to supply air as required. The licence was one by which no payment was to be made for the Houghton Mill so long as no change was made in the application there of the exhausting arrangements, but by which at their other mills the patentees might work Bovill's patented inventious on terms. By this licence Mr. Bovill expressed his unreserved concurrence in Mr. Brown's assertion that what was done at the Houghton Mill was no infringement of his patent of 1849. The Vice-Chancellor we see believed the testimony that the exhaust was used. In Crate's suit he was of opinion it was impossible to have a plenum if there were holes in the mill-stone case. We here find him expressing an opinion that "by these holes he got a contrivance by which the plenum should be exactly exhausted and no blast occasioned;" but that this did not invalidate Mr. Bovill's patent because the contrivance by which he effected it was of a different character. This means that Mr. Bovill's invention was not for the process of exhausting the plenum (begging our readers' pardon for using an unmeaning expression), but for the particular apparatus by which the plenum was exhausted. On the second trial of *Bovill* v. *Goodier*, Mr. Justice Byles directed the jury that they were bound to believe Mr. Brown's testimony, but that what he had done in and since 1846 was no evidence of anticipation of Mr. Bovill's invention, because that invention was not an invention of the apparatus (which was the same as Mr. Brown used), but of the process of exhausting the plenum! To complete the view of the administration of justice we mention that Lord Cairns, on the appeal in the present case, stated that, beyond doubt, if Messrs. Brown were to be believed, the Houghton Mill did anticipate Mr. Bovill's patent, but he, who had never seen either of them, rejected their evidence as incredible, inasmuch as they had accepted the licence!

The Vice-Chancellor was so well disposed to Mr. Bovill that the very sagacious counsel who appeared for him was determined to commit his Honour as deeply as possible, and our note of the judgment in *Bovill* v. *Smith* next shows the following suggestion:—

"Mr. Grove: Sir, I ought to mention this, as your Honour has now gone through all the cases, there is the case of Mr. Kingsford, but my learned friends have not mentioned it. Your Honour will remember, it was Newton's case, and it was stated in Mr. Bovill's evidence to be Newton's exhaust.

"The Vice-Chancellor: I was looking at it last night, but I forget the name of the witness at this moment.

"Mr. Grove: It is mentioned in Horn's evidence. He mentions what Mr. Bovill did. Mr. Newton was a Patent Agent, who really was a trustee for him.

"Mr. Aston: Your Honour will find it at page 12, paragraph 2—the second paragraph from the top of the page.

"The Vice-Chancellor: Yes, I have it. Mr. Horn's evidence begins at the bottom of page 11, and he says this—'I know the plaintiff's patent of 1849, and I have always understood that the invention protected by the plaintiff's said patent was of an exhaust, applied to millstone cases to remove the stive and plenum of air caused by a blast of air forced by an independent blowing machine between the grinding surfaces of the stones, and for a stive room made of porous fabrics, to admit of the straining of the flour dust from the air of the stive. I say that it was not a new invention in 1849 to apply a pipe from a fan as an exhausting machine to the cases of millstones, so as to carry off the warm dusty air in the millstone cases, and to allow the meal to descend through the open meal spouts free from stive, which was carried to a chamber wherein the flour particles were economised, for I say that early in the year 1848 I saw those things done as part of the ordinary and constant practice at Messrs. T. and C. Kingsford's Tide Mill, at Deptford.

"Mr. Grove: Your Honour remembers he says 'they were carried away,' but he does not say a good deal more was not carried away. This is consistent with Mr. Newton's patent.

"The Vice-Chancellor: That witness's evidence comes just at the bottom of the page. I will just refer to it, as no comment has been made upon it. Will you tell me which affidavit of Mr. Bovill relates to it? I think there is more evidence about Kingsford.

"Mr. Grove.—Your Honour had the case of Kingsford mentioned in *Bovill* v. *Crate*.

"The Vice-Chancellor: Yes, it was, I think. I paid very little attention to it, I confess.

"Mr. Druce : The statement about Mr. Kingsford begins at paragraph 10, page 4, 'A very large number of millers and others interested in the milling trade.'

"The Vice-Chancellor : 'A very large number of millers and others interested in the milling trade were present at such trial, including a Mr. Charles Kingsford, who was put into the witness-box as a witness on behalf of the defendant, but not examined by either side, and Mr. Wren and his millwrights, who were not called as witnesses.' Is that all he says?

"Mr. Druce : It was in the Privy Council. That appears afterwards.

"The Vice-Chancellor : It occupied such very little time in discussion, in the former case, and none at all in the present, that I confess I have very little attended to it. Nobody has mentioned it in the course of the defendant's argument, but I should just like to look at it.

"Mr. Grove : Your Honour will find it at paragraph 10. It is stated he was present at the trial of *Keyworth* and *Seely*.

"The Vice-Chancellor.—I do not find any more about it.

"Mr. Grove : I think there is something in that. It states he is an assignee of somebody else.

"The Vice-Chancellor : It is stated 'it was not a new invention to apply a pipe or a fan.' Of course it was not. That is an exhaust machine.

"Mr. Grove : At page 7, line 23, it is said that Charles Kingsford was examined in the Privy Council. Then at page 8, in *Swaine and Bovill* v. *Christie*, Mr. Charles Kingsford gave evidence on behalf of Christie against him.

"Mr. Druce : Will your Honour look at page 31 of the second affidavit of Mr. Bovill, which begins 'Improvements upon the manufacture?'

"The Vice-Chancellor : Yes, this is it. 'A patent agent, Mr. Newton, in his own name, but in fact on behalf of Messrs. Gensdebien and Houyot, took out a patent, in which patent, very shortly afterwards, a Mr. Charles Kingsford, hereinafter mentioned, obtained an interest, for creating a strong current of air down the eye of the top or runner stone, and between the stones, by means of a vacuum or powerful exhaust, applied to the side of the mill-stone case, making the cases air-tight, so as to cut them off from any connection with the external air, to secure a powerful vacuum exhaust.'

"Mr. Grove : Your Honour will find that Mr. Horn's evidence is quite consistent with that.

"The Vice-Chancellor : I am going to look at Mr. Horn's evidence—'I say that it was not a new invention in 1849 to apply a pipe from a fan, as an exhausting machine to the cases of millstones, so as to carry off the warm dusty air in the millstone cases, and to allow the meal to descend through the open meal spouts, free from stive, which was carried to a chamber, wherein the flour particles were economised, for I say that early in the year 1848 I saw those things done as part of the ordinary and constant practice at Messrs. T. and C. Kingsford's Tide Mill at Deptford.' The same observation applies to that, that applies to Cabanes' and the other patents. You may have exhausts simply for the purpose of exhausting the plenum, taking care to do no more. It is clear, coupling all those circumstances together, what did take place. Kingsford was interested in Newton's patent, and what he is describing there is Newton's patent, and not the plaintiff's."

We believe this to be unique. Whilst delivering judgment, and not before, does the learned Judge give his attention to the evidence :—

"Now as to the infringement I have got but one word to say upon it—that is, with reference to an argument which was used by Mr. Little arising on my former judgment. He quoted the passage at page 22, in which I said that as Mather had described the apparatus in the first part of his evidence, you there had the plaintiff's patent, because he described the fan as within the tube, and that tube as immediately connected with the millstone case, whereas in reality what existed at Isleworth was this—a tube going through the millstone case into a horizontal tube, another upright tube going from that through a chamber with bunting or something of that kind—a porous fabric—then another tube from the chamber with the porous fabric up to the top of the building, where there was the fan, and that was a totally different apparatus, as I stated in my judgment, as it struck me from what the plaintiff had said. Mr. Little pressed me, and said what the plaintiff does is exactly that which was described by Mather (although it turned out not to be the fact) at Isleworth. I will turn to the evidence which was given, as I do not remember the thing quite correctly. It is stated at page 22 of my judgment in *Bovill* v. *Crate*. The evidence was 'except that we found that the warm air or stive was not sufficiently active to ascend the entire distance into the said stive-room, so as to sufficiently clear the stone-cases, and notwithstanding I and the said Samuel Kidd had been desirous to obtain this end without the employment of mechanical means, we found it impracticable, and we therefore fixed a fan in the vertical spout leading from the said trunk into the stive-room,and which fan was worked by means of the steam power used for driving the mills.' That is the plaintiff's patent, and that is the identical thing no doubt which is described. They have got the tube, they have got the fan, and this is below the stive-room; it is in the spout leading to the stive-room; it is working away in the stive-room, and takes the air through the stone-cases and drives it into the stive-room exactly as the plaintiff's does. The comment I wish to make on that is simply this: it was rather with reference to another part of the case, as showing a previous invention in the design which Mr. Little pressed me with. The same argument applies there which I have already dealt with in Cabanes' and Debeaune's cases. In Debeaune's case Mr. Little pressed me with this—that Debeaune had done equally what I said before was a description of the plaintiff's patent. Then the point that arises is exactly similar to what arises in Debeaune's design. Debeaune has not told you the qualifying process by which you are to exhaust and nothing more. In the Isleworth case I have had a good deal of evidence to show that there was a qualifying process; that a man was sent upstairs to see that the number of turns made was proper, that it should not go too fast or too slow; that a candle was applied downstairs. It is perfectly true that I did not take in the whole of that. The evidence was strong that a man did go with a candle and made the experiment, so that if you couple all those experiments with the exact nice adjustment and description, you have got the whole thing; but I am of opinion that that was impossible to have occurred. If there could have been an adjustment of that kind, in consequence of the intervening space through which the air had to be withdrawn, that would have interfered, and would have entirely frustrated the possibility of your adjusting the exhaust in the manner described, there being that intervening space before you come to the porous fabric. I had almost forgotten that, but I am glad I have just remembered it.

"Now, as regards the actual infringement, the point which Mr. Little insisted upon, and also Mr. North, is the one test of the plaintiff about infringement is as follows—whether or not the stive is cleared away from all parts of the machine so that you have the mill in a healthy clean state; with no heat, no dust, no waste of flour, and no nasty sour paste, and so on. That is not so in the defendant's mill—there it is not clear. The plaintiff's witnesses speak to this, and it is not contradicted that the millstone case was quite clear, and the meal itself quite free from stive; all that had been achieved, but the plaintiff himself said nothing about the higher part of the apparatus. The higher part of the apparatus seems from Mr. Bramwell's evidence to have been clogged with paste and dust, as in the Isleworth case, and the thing was not sufficiently done. The difference between the Isleworth case and this case of infringement is just this: in the Isleworth case it never could have been done, as I have held on the evidence before me, the apparatus was not such as could possibly have achieved it. Nothing of the kind could occur. The plaintiff's invention could not have been exercised with such a set of contrivances as those gentlemen set up, with the intervening gap of a room with an open porous fabric, which would have completely prevented the application of the exhaust in accordance with the patent of the plaintiff. As I said before when the plaintiff's patent came out, they found they had failed, and they then introduced and used an apparatus exactly similar to that of the plaintiff. In this case there is everything put up which could exactly effect what the plaintiff does, and as to that I would refer to the passage I just read from the judgment, everything is done which can effect the plaintiff's process. There are slides, those slides may be badly manipulated, they may not have always manipulated them to the right point, but the right point being that you are to exhaust and do no more, but so manipulated they have been, as to effect one object of the plaintiff's patent—all the stive is cleared away, and the moment you shut the slides all the stive comes down so that when you make it impossible for him to use the apparatus of the plaintiff by the plaintiff's method, then his mill is smothered with stive; when he uses the slides in such a way that it can exactly perform what the plaintiff does, the effect is to remove all the stive at once, but it had not so far the effect when the practical experiment was made as to remove all the damp and all the corrupted flour. I suppose from Mr. Bramwell's evidence, which I do not in any way, as I said before, question at all, it never has been used entirely effectively in that way because he comments upon the state of the timber in the mill, which shows by indications upon it the effect of damp, and therefore it is clear the damp could not have been wholly carried away. But the question is whether the partial use is or is not an infringement? Now I can quite understand this, that the plaintiff is tied down to a very narrow line indeed, because that is the only way of doing the thing effectively, but when the thing is quite nicely and effectively done, and will clear the whole concern, not only of the stive but also of the damp and the heat sufficiently to prevent the accumulation of moisture, it is not because a person has an apparatus which if properly used will produce that effect, through the medium of slides which will produce one object, namely, the removal of the stive, that he is to escape from his infringement. Because that is done effectively, and when the slides are closed and the apparatus is not made use of the mill is covered with dust and stive, a person cannot by using it in that way escape from the infringement of the patent, that is to say, simply because he does not make use of it so effectually and completely as the plaintiff does. It appears to me as regards the infringement the apparatus is exactly that which does effect what the plaintiff's does; it does effect that portion of it to that extent if worked. If it is not worked more completely there is no reason why he should be allowed to use one portion of the apparatus and leave the other half unaccomplished; he is just as much prevented by the law from using the patent to the extent which I have described, as he is from using it to the fullest and completest extent. The line to which the plaintiff is tied down is not so narrow as to allow a person to come upon the very verge of it and say, I will take just half of what you do, and I will not complete the operation, which if carried into effect by your instrument is so very beneficial.

"Now, I have only one other observation to make. This really is *Bovill* v. *Crate* over again. This matter has been tried over and over again in different Courts, but no doubt it comes on now in an imperfect form for the Court of Equity to arrive at a conclusion upon it. It comes on as a cause and not as a motion for decree, therefore the affidavits do not answer each other, but each side produces its own evidence. There is rather more notice in the plaintiff's bill than there is in the answer, but there is not full notice undoubtedly in the plaintiff's bill of a good many things which have been given in evidence. No notice whatever is given by the defendant's answer, and according to Lord Cottenham's view, what a Court of Equity should do in such a case as this, the evidence would not be excluded if it is not put in issue, as was once the notion in our Courts, but the rule now seems to be established that you should give any party who is taken by surprise an opportunity of meeting those matters which he states has taken him by surprise. It is impossible in this case for me to hold that any party was surprised on one case or the other. No doubt Mr. Bovill may have been somewhat surprised by Debeaune—that is the only thing, I should say, that took him by surprise. As to the defendants, I cannot trace a single document as to which it can be said they have been taken by surprise, by what has come out here. They cannot have been taken by surprise by anything Mr. Muir has said or done; and there is not anything I can see to lead me to say that these parties have not come to trial with every possible point suggested which has arisen during the period of ten years which has elapsed since the trial of *Bovill* v. *Keyworth*, and during the whole of which time the plaintiff has been in constant litigation. I confess I do not think I ought to prolong that period of litigation by any technical notion that the parties were not fully prepared. I have the evidence of the combination, and so on, fully before me. This gentleman is one of the combination, or I should rather say he subscribes to it. Therefore I must hold that both sides were fully informed, both Mr. Bovill and the defendant, that the case was ripe for decision; and having come to that conclusion, that the case is exactly the same as *Bovill* v. *Crate*, the decree will also be exactly the same."

(*To be continued.*)

LONDON ASSOCIATION OF FOREMEN ENGINEERS.

At the dinner of the Foremen Engineers, on the 19th ult., Sir Joseph Whitworth made the following observations:—During the last two years trade has been in a very depressed state, and both employers and employed have suffered much. I am happy to say that there are now signs of improvement in most branches of industry, and, if we are favoured with good harvests this year, the improvement will now go on and increase. The prosperity of England depends, not only on the produce of her soil and mines, but also greatly on the number of self-acting machines she keeps at work. In proportion to the increase of the latter has been her increase in wealth and power. Our ancestors had very rude implements to work with, but since the introduction of the steam-engine the machinists and engineers of England have gone on applying new machines to every kind of industry, until we have arrived at a time when we have an enormous wealth-producing power at our command. The produce of our mines of coal and iron is so abundant that we can convert the raw material we obtain from other countries into an almost endless variety of things, which add to the comforts of all. The wealth derivable from our mines and self-acting machinery goes on without interruption. The produce of the soil everywhere greatly depends on the seasons. Hence the desirableness of having the most extended area for the exchange of our manufactures. The progress that has been made by engineers during the last forty years has been very remarkable, particularly in constructing and making self-acting machinery. Twelve shillings per foot were then paid for the labour of chipping and filing surfaces of iron, which is now frequently done on the planing-machine for 1d. By Mr. Bessemer's admirable process, the cost of manufacturing some kinds of steel has recently been reduced to one-half, and in some cases to one-third what it used to be. The consumption of coal for manufactures has been reduced more than one-half; the saving last year on the English railways by locomotive engineers burning coal instead of coke was £1,200,000 sterling. Mechanical and civil engineers, chemists, and scientific men are continually finding out new modes of producing wealth, and the owners of self-acting machinery generally go on improving and increasing their productions, from which those who have fixed incomes derive great advantage. Until the corn laws were repealed legislation was not in accordance with the proper development of self-acting machinery. The full employment of such machinery requires a free exchange for the produce of all countries. Engineers have so reduced the cost and time of transit that when we have this free exchange England will probably be the cheapest country in the world to live in. The taxing of imports has long appeared to me very illogical and paradoxical, seeing that the labour of 1,000 men employed in cultivating the soil in foreign countries could in many cases be obtained for the labour of one man in this country employed on a self-acting machine. Under such circumstances as these a tax on exports rather than imports would seem to have been more logical, but I am against both. I mention these considerations because it is my conviction that, next to the study of those sciences more immediately connected with the engineering profession, that of political economy most deserves the study of engineers. Looking to the immediate future, we may congratulate ourselves on the great opportunities that are arising for the development of engineering enterprise. The cultivation of the land by steam power is greatly on the increase, landed proprietors now seeing the importance of so clearing and improving their estates as to admit of this. The use of horse tramways is being urgently pressed forward, and a large outlay is contemplated. In my opinion they are not suited to the present times, and mechanical engineers have a right to enter their protest, considering the many obstructions there have been for many years past to the employment of road locomotives. If tollgates were abolished, and each county had an organised staff for making and keeping the roads in good order, using the steam roller, steam sweeping machine, and other necessary appliances, where there is large traffic, mechanical engineers would then, I have no doubt, soon produce a small light locomotive that would do its work quietly and most effectively; at the same time pedestrians and those who ride and drive would have the great enjoyment of good and clean roads, instead of the present badly paved and rough Macadam roads. The broken stones of the latter are now left for the horses' feet and narrow wheels to consolidate, in a way which it is quite distressing to see. The consumption of fuel per horse-power is now so small that road locomotives could be employed at far less expense than the overworked and ill-conditioned horses we now see, while pedestrians and those who keep animals for pleasure would have good roads, and many gentlemen, no doubt, would have their well-made locomotives. Under any circumstances good clean roads are the most profitable when everything is taken into account; but, unfortunately, those who make and repair them generally consider only one side of the question.

SHIPBUILDING ON THE THAMES.

The first of the fleet of steamships building in this country for the "Compania de Navigacion a Vapor Italo Platense" was launched on Jan. 31st from the building yard of Messrs. J. and W. Dudgeon, shipbuilders and engineers, at Cubitt-town, in the presence of a large number of gentlemen and ladies, many of the former being interested by business pursuits and otherwise in the means of communication by sea between the Italian coasts in the Mediterranean and the River Plate. The vessel was named the *Italo Platense* in a very graceful manner by Madame de Murietta, and a blessing, according to Italian custom, was invoked upon her future career by the Bishop of Troy. The *Italo Platense* is a remarkably handsome vessel of 1,600 tons, of large carrying power, combined with fine lines for speed. She is 270ft. long by 34ft. in breadth, and is fitted with independently working twin screw engines, designed and manufactured by the Messrs. Dudgeon, of 370-horse power nominal. Two other vessels for the same company, of similar dimensions to the *Italo Platense*, are building by the Messrs. Dudgeon, and a fourth vessel, of somewhat larger tonnage, is about to be laid down by them. The vessels of the Compania de Navigacion a Vapor Italo Platense are intended to run between Genoa and other Italian ports in the Mediterranean and the River Plate, and develope what is believed to be a very large and important commerce. The Italian Government are in treaty with the company for the conveyance of mails between the Italian and South American ports.

On the 2nd ult. a numerous company assembled at the shipbuilding yard of Messrs. Maudslay, Son, and Field, East Greenwich, to witness the launches of a sailing ship named the *Blackadder*, and a barque, the former built for Messrs. Willis and Brothers, and intended for the China tea trade, and the latter for Messrs. Scrutton and Campbell, intended for the West India trade. Both launches were most successfully managed, the ceremony of christening the vessels being respectively performed by Miss Willis and Mrs. Alexander Scrutton. The principal dimensions of the *Blackadder* are—200ft. between perpendiculars, 35ft. beam, and 21ft. depth of hold, her registered tonnage being 940. The barque is 145ft. between perpendiculars, 28ft. beam, and 16¼ft. depth of hold, her register being 486 tons.

AMERICAN GEOGRAPHICAL AND STATISTICAL SOCIETY.

The annual general meeting of this society was held at New York, on the 26th of January, when the president, Judge Daly, delivered the inaugural address, in the course of which he enumerated the following events as making the year 1869 peculiarly memorable:—1. The connecting of the North Atlantic with the Pacific Ocean by rail. 2. The completion of the canal across the Isthmus of Suez. 3. The exploration and discoveries in South Eastern and East Equatorial Africa. 4. The additional and conclusive evidence now brought to light of a climate in the icebound regions of the Arctic, at a past and remote period of time, resembling that of the countries lying near the equator. 5. The marvellous results of the deep sea dredging of Professors Thompson and Carpenter, revealing the existence of animal life at enormous depths in the ocean, where we should have supposed the existence of life to have been impossible. 6. The very general disturbances throughout this year of the earth's surface by earthquake, distinguishable not so much for its effects in particular localities as for the distribution of the phenomena over the globe, and its appearance in parts of the world where such disturbances have never been previously witnessed within the memory of man. 7. The attractive power of mountains discovered in the pendulum experiments made during the past year at the observing stations upon the Himalayas in India. 8. The discovery through the spectroscope of a method determining the proper motion of the stars and the fact that the physical and chymical construction of the whole stellar universe is identical. 9. The invention and successful practical use of a self-registering compass by which every motion of a vessel can be recorded and preserved from the beginning to the end of her voyage. 10. The discovery of trees of enormous height and magnitude in Australia, one of which was found to be 69ft. in circumference. 11. The discovery of great deposits of coal throughout the whole of New Zealand, and the finding of coal upon the borders of the Caspian Sea, verifying in this last particular a prediction of Humboldt's, both of which discoveries are of the highest importance to commerce. 12. The anthropological researches in Europe, Asia, and Africa, revealing the structure and mode of life and customs of the earliest inhabitants of the earth. 13. The passage and escape of the American ship *Congress*, last August, through a cyclone of extraordinary intensity and power, in the Atlantic, under circumstances which afford a great deal of information upon the time of the formation and movement of this terrible phenomenon of the ocean.

REVIEWS AND NOTICES OF NEW BOOKS.

Gisement, Extraction et Exploitation des Mines d'Houille, Traité pratique à l'usage des Ingénieurs, des Contre-maîtres, Ouvrieur Mineurs, &c. Par M. Demanet, Ingénieur. Paris: Eugene Lacroix.

An interesting treatise upon the working of coal mines. An account is given of the coal deposits existing in Belgium, the North of France, and the department of the Loire. The means employed in working the mines and getting the coal are described tersely, yet with a certain degree of minuteness.

Atchley's Builder Price Book, 1870. London: Atchley, & Co.

By the means of this useful work of reference, it seems quite a simple affair to calculate the cost of any operation in the building line, from the smallest repair to the erection of an extensive mansion, Almost everything possible to be brought into use is herein described and priced. In this edition a noticeable feature is a list of timber marks, by which the qualities of various timbers may be at once recognised. A treatise upon the application of iron to building purposes is also given.

Scientific Studies. By Henry Dirckbs, C.E., &c. London: E. & F. N. Spon.

Two lectures—the first being upon the "Life of the Marquis of Worcester," inventor of the Steam Engine.

The vicissitudes of the Noble Marquis, who spent his life and fortune in mechanical invention are here graphically described. The final triumphs of his labours culminated in what he termed the "Water-Commanding Engine," which it appears was erected at Vauxhall, in or about 1667, which is described in his application to Parliament for assistance to work out "his great invention of a Steam Water-Raising Engine," set up at Vauxhall, and to project a public company for obtaining funds sufficient to extend its utility to the supply of towns and canals, and for draining mines and marsh lands. From this it would appear that the first practical application of steam was in the matter of water supply. The inventions of the Marquis were not confined to his "Water Commanding Engine," for it is stated in his "Century of Inventions," tha the claims to have *tried and perfected*, inventions which refer to seals, watches, games, arithmetic, perspective, automata, a self-acting mechanical contrivance, cipher correspondence, signals, secret writing, telegraphs, inventions applicable for domestic use, naval and military affairs, and hydraulics.

The second lecture is a treatise on the chimeras which in the name of science were propounded in the middle ages, combining those of astrology, alchemy, squaring the circle, the perpetuum mobile, &c., which occupied the attention of the pseudo-scientific men of the day, who deluded either their patrons or themselves. The alchemists devoted their attention to the production of the *lapis philosophorum*, which for upwards of ten centuries was sought with the idea of converting the baser metals into gold, others turn their attention to medical alchemy,—which was to produce the *elixir vitæ*, a liquid which should prolong human life indefinitely by producing renewed juvenescence—others again to the fascinating study of perpetual motion, and in the dark ages—before the printing press was at hand, spreading light over the world—inventors were reproducing the same designs, not knowing that similar ideas had occurred to others before them.

CORRESPONDENCE.

We cannot hold ourselves responsible for the opinions of our Correspondents.

Sir,—My attention having been called to some remarks concerning the "Field" patent boiler, in a recent article on yacht boilers in your valuable journal, I beg to say that I am fully prepared to practically demonstrate beyond a doubt to any one who will favour me with a call, that the Field tubes will, within a very short time after lighting the fire under them, clear themselves of any solid particles of foreign matter that may have been allowed to settle within them.

Hoping that you will kindly insert this explanation.

I am,
Your obedient servant,
W. Lloyd Wise, H.S.M.I.E.,
Representative of the Patentees.

NOTES AND NOVELTIES.

MISCELLANEOUS.

Rubber Tubes Made Gas-Tight.—M. Jouanne's method is to give the tube a thin coating of a varnish made by dissolving two parts of gum arabic and one and a half of treacle in seven parts of white wine and three and a half of strong alcohol. The alcohol is added slowly, and at the last,—and with constant stirring, or the gum will be thrown down.

Oil Boring in Pennsylvania.—The methods used in boring are constantly changing and are in some respects quite different now from what they were five years ago. The derricks are built higher and wider, as the wells are generally deeper, and the tools longer and heavier. Wells are bored quicker now than then; instead of five or six months, a well is now bored nine hundred feet deep in forty-five to sixty days. The crude oil is no longer shipped in barrels, but wholly in bulk, in large iron or wooden tanks on the railroad. The refined oil, however, goes in barrels.

Biarritz.—The streets of the town of Biarritz are about to be lighted with gas for the first time. The first stone of a gasometer was laid on the 10th of January.

There will be five new lighthouses on the coast of Egypt, in consequence of the Suez Canal; viz., at Port Said, Rosetta, Burlos, Damietta, and Razel-Bouroum.

The Northern Iron Trade.—On the 11th ult., arrangements were arrived at without an adjudication by Mr. Hughes, by which it was agreed that the men should have an advance of 10 per cent. in their wages for twelve months from January last to January next, the agreement to bind both parties for that period.

To Australia by Rail and Steamship.—A private meeting of influential merchants and others was held a short time ago at the London Tavern to discuss the projected steam communication with Australia and New Zealand *viâ* Milford Haven, Portland, and San Francisco, within 40 days; Sir George Grey in the chair. It was numerously attended, and, after lengthened explanations of the details, the following resolution was unanimously adopted: "That this meeting highly approves the proposed route to Australia and New Zealand *viâ* Milford Haven, Portland, and San Francisco, and recommends that steps be forthwith taken to establish a company to carry the same into effect.

MILITARY ENGINEERING.

The Moncrief Gun Carriage.—The first of the wrought-iron carriages and platforms for 12-ton rifle muzzle-loading guns, manufactured in the Royal Carriage Department, Royal Arsenal, Woolwich, under the superintendence of Col. H. Clerk, Royal Artillery, from designs furnished by Capt. Moncrieff, of the Edinburgh Militia Artillery, was submitted on January, the 24th, to a private trial at the proof butts in the Government marshes at Plumstead, for the purpose of ascertaining the amount of counterweight required. Three rounds were fired, without any alteration being required, with projectiles of 250lb. weight, and increasing charges of 30lb., 35lb., and 40lb. of powder, the carriage working with the most perfect ease and regularity. At the last round fired a fracture was observed in the axle, near the right cheek of the carriage. The trial, as far as the general principles of the carriage are concerned, was highly satisfactory. The total weight of the platform, elevator, carriage, and gun amounted to nearly 50 tons.

RAILWAYS.

Russian Railways.—It is announced that the Russian Government has just decreed a considerable extension of the railway system in the Caucasus and elsewhere, in order to open up the country and promote trade.

The block system is being introduced on the Brighton line, and is already in operation at some important places on it.

Greenwich and Woolwich Railway.—A letter from Mr. Vernon Lushington, on behalf of the Admiralty, has been received, in which it is stated that the Lords Commissioners have given directions to their solicitor to take the necessary steps for opposing the bill for the construction of the above line. The letter also states that the proposed scheme is nearly similar to that which was opposed by their lordships in 1868, on account of the serions injury it would have caused to the Royal Observatory.

The Midland Railway.—On the 1st ult., a new line of railway, which has been constructed between Sheffield and Chesterfield, was opened. Through the agency of the new line the valuable result will be effected that Sheffield will be placed on the main thoroughfare of the Midland Railway. In addition to the advantages afforded in accommodation for passengers at stations, the Midland Company will be enabled to provide increased facilities for travelling. The time occupied in the journey from Sheffield to London by the Midland will be exactly the same as that taken up by the Great Northern.

The Secretary of State for War has accepted the tender of the Fairbairn Engineering Company for the iron work of the first of the great armour-plated forts at Spithead.

TELEGRAPHIC ENGINEERING.

The Cuba Submarine Telegraph Company.—A prospectus has been issued of the Cuba Submarine Telegraph Company, with a capital of £160,000, in shares of £10, to lay a cable of 540 miles from the western to the eastern points of the island, the former to communicate with the American line from Havannah to Florida, and the later with the West India and Panama line from Santiago de Cuba to Jamaica, thus obviating the necessity for using the internal land lines for foreign messages. An exclusive concession for forty years has been granted by the Spanish Government, and working arrangements have been entered into with the American and English Ocean Companies. The cable is to be constructed by the India-rubber, Gutta-percha, and Telegraph Works Company, and is expected to be laid within the next fonr months.

Telegraph to the Channel Island.—A prospectus has been issued of the Jersey and Guernsey Telegraph Company (Limited), with a capital of £30,000 in shares of £2.

Government and the Telegraphs.—The amounts paid by the Government for the telegraphs are as follows:—

Electric and International Telegraph Company	£2,938,826
British and Irish Magnetic	1,243,536
Reuter's Telegraph Company	726,000
United Kingdom	562,264
Universal Private	184,422
London and Provincial	60,000
Total	£5,714,048

The prospectus has appeared of the Manila and Hong-Kong Submarine Telegraph Company (Limited), with a capital of £350,000, in 35,000 shares of £10 each. The company has been formed to purchase and carry out an exclusive concession, granted for forty years by the Spanish Government, to establish telegraphic communication between Manila, Hong-Kong, and Singapore, and it is now proposed to complete the first section from Hong-Kong to Manila, about 650 nautical miles, together with connecting cables to adjacent islands, and land lines, estimated at a further length of 470 miles. It is pointed ont that communication with Europe, England, and America will be established by more than one ronte, either through the system of the British Indian, the Anglo-Mediterranean, and the Falmouth, Gibraltar, and Malta Companies—by Galle or by Calcutta—or along the Great Northern Company's lines through Siberia. Calculations based on the great commercial importance of Manila, the Philippine Islands, and other places to be connected, show, it is stated, that a large annual income may be anticipated from this section. The second section of the undertaking, from Manila to Singapore, by Labuan and Sarawak, is reserved for after-consideration, should the wants of the through traffic seem to demand the extension.

A prospectus has been issued of Hooper's Telegraph Works (Limited), with a capital of £250,000, in 25,000 shares of £10 each. The company is formed to take over and extend the works of Mr. William Hooper, for the manufacture of India rubber core for telegraphic purposes, and to add the business of making and laying submarine cables.

DOCKS, HARBOURS, BRIDGES

Suez Canal.—According to official returns the receipts of the Suez Canal since the opening, and made up to the 31st Jannary last, amonnted to 567,872f. 6c., accruing from: 1. Tolls on vessels; 2. Transit of merchandise and passengers; 3. Rent of property and houses. The last item figures only for the sum of 48,860f. 81c.; but so soon as the question of judicial reform in Egypt has been disposed of, and the lands pertaining to the Canal Company can legally be sold, the income derived from this source alone cannot fall to be of considerable importance. As regards the navigation of the canal, it may be said to be as yet in its infancy; nevertheless it is progressing. Between the dates of the 21st November and 31st January twenty-six vessels, or equal to one every three days, passed through; and from the 1st to the 17th February nineteen vessels, or little more one vessel per day.

The Suez Canal.—It is stated that the directors of the Peninsular and Oriental Company intend to start a line of traffic steamers between England snd India *viâ* the Suez Canal, and that a branch head quarters office is to be established at Liverpool. The homeward bound French steamer from Bombay for Marseilles, *via* the Canal, had many passengers on board. The *Malta Times* of January 19, reports that the partisans of the French lines confidently affirm that they will soon take both passengers and goods traffic out of the hands of the Peninsular and Oriental Company, but the *Malta Times* is of opinion that with an energetic superintendent at Liverpool the Peninsular and Oriental wonld soon have the great majority of the export and import trade with the East in its own hands.

APPLIED CHEMISTRY.

Easy Method of Removing Gypsum from Water.—The use of witherite, native carbonate of baryta, is recommended by Dr. Riecker, to remove all the gypsnm from water. Of course the quantity of the mineral to be applied for this purpose should be regulated according to the quantity of gypsum present in the water; bnt, as an instance, we may state that a water containing, in 10,000 parts, 4·37 parts of gypsum, requires about ½lb. of witherite, ground to a fine powder, for every large pailful of that water. After the addition of the witherite, the water is well stirred, and next left at rest to deposit the sediment for twenty-four honrs, and then run off for use. The water may be either boiled before or after this process, and will be found quite soft.

Cast-iron Stoves.—Dr. Saco mentions that some experiments made in his laboratory fully prove that cast-iron stoves, even if they are allowed to become red hot, are not injurious to health, provided care be taken to ensure a proper ventilation and draught in the chimney, or, rather, in the pipe leading from the stove into it. The use of cast-iron stoves, Dr. Saco says, is not injurious to health, but becomes so only with imperfect draught; and that defect impairs the good use of all kinds of stoves, no matter whether they be made of cast or wrought-iron, or of any other material.

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	s.	d.	To £	s.	d.
COPPER.						
Best selected, per ton	71	0	0	73	0	0
Tough cake and tile do.	69	0	0	71	0	0
Sheathing and sheets do.	76	0	0	„	„	„
Bolts do.	77	0	0	78	„	„
Bottoms do.	79	0	0	„	„	„
Old (exchange) do.	63	0	0	„	„	„
Burra Burra do.	73	0	0	„	„	„
Wire, per lb.	0	0	10	„	„	„
Tubes do.	0	0	11	„	„	„
BRASS.						
Sheets, per lb.	0	0	8½	0	0	9
Wire do.	0	0	7½	„	„	„
Tubes do.	0	0	10½	„	„	11½
Yellow metal sheath do.	0	0	6½	0	0	6⅞
Sheets do.	0	0	6½	„	„	„
SPELTER.						
Foreign on the spot, per ton	19	5	0	19	10	0
Do. to arrive	19	15	0	20	0	0
ZINC.						
In sheets, per ton	24	0	0	„	„	„
TIN.						
English blocks, per ton	116	0	0	117	0	0
Do. bars (in barrels) do.	117	0	0	118	0	0
Do. refined do.	119	0	0	120	0	0
Banca do.	115	0	0	„	„	„
Straits do.	114	0	0	115	0	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	6	0	1	7	6
IX. do. 1st quality do.	1	12	0	1	13	6
IC. do. 2nd quality do.	1	5	6	1	6	6
IX. do. 2nd quality do.	1	11	6	1	12	6
IC. Coke do.	1	2	6	1	3	6
IX. do. do.	1	8	6	1	9	6
Canada plates, per ton	13	0	0	14	0	0
Do. at works do.	12	0	0	13	0	0
IRON.						
Bars, Welsh, in London, per ton	7	5	0	„	„	„
Do. to arrive do.	7	5	0	„	„	„
Nail rods do.	7	5	0	7	10	0
Stafford in London do.	8	5	0	9	0	0
Bars do. do.	8	0	0	9	0	0
Hoops do. do.	8	17	6	10	15	0
Sheets, single, do.	9	15	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	0
Bars, common, do.	6	15	0	„	„	„
Do. mrch. Tyne or Tees do.	6	10	0	„	„	„
Do. railway, in Wales, do.	6	12	6	7	0	0
Do. Swedish in London do.	10	0	0	10	2	6
To arrive do.	10	0	0	„	„	„
Pig No. 1 in Clyde do.	2	18	6	3	5	6
Do. f.o.b. Tyne or Tees do.	2	9	6	„	„	„
Do. No. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	10	0	5	15	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pig in London do.	6	0	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	13	15	0	„	„	„
Do. (hammered) do.	14	15	0	„	„	„
Do. in faggots do.	15	15	0	16	0	0
English spring do.	17	0	0	23	0	0
Quicksilver, per bottle	6	17	0	„	„	„
LEAD.						
English pig, common, per ton	18	15	0	„	„	„
Ditto. L.B. do.	19	0	0	„	„	„
Do. W.B. do.	19	10	0	„	„	„
Do. sheet, do.	19	10	0	19	12	6
Do. red lead do.	20	0	0	20	10	0
Do. white do.	27	0	0	30	0	0
Do. patent shot do.	22	0	0	„	„	„
Spanish do.	18	5	0	„	„	„

*At the works 1s to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated January 22nd, 1870.

209 A. S. Campbell—Facilitating the working of bicycles
211 W. Warren—Anchors
212 J. Holdsworth—Discharging grain and other materials
213 W. R. Lake—Reaping machines

Dated January 24th, 1870.

214 R. Boyd—Bells
215 W. R Lake—Railway switches
216 R. S. Dale and C. Schorlemmer—Preparing colouring matters
217 T. Bentley—Decanting liquids
218 W. E. Gedge—Lubricating parts of locomotive engines
219 F. Kohn—Extracting juices from plants

Dated January 25th, 1870.

220 G. E. Harding and P. Wright—Knitting machines
221 J. H Johnson—Applying anti friction rollers to wheels of machinery
222 G. C. Philcox and T. Saint—Chronometers, &c.
223 J. Skertchly and A. M. Hurst—Manufacture of tablets
224 W. Hunter—Looms
225 H. B. Greenwood—Telegraphs
226 R. A. Whytlaw—Feeding steam boilers with water
227 J. Strain—Pipe joints
228 C. F. Varley and T. A. Rochussen—Producing heat
229 G. A. Buchholz—Manufacturing semolina and flour
230 W. S. Underhill—Steam engines
231 A. V. Newton—Meters
232 F. J. Barnby—Floor cramps

Dated January 26th, 1870.

233 W. G. R. Penley—Pipes
234 W. Hay—Making paper
235 W. R. Lake—Grates
236 W. E. Newton—Preparing surfaces for skating in all seasons
237 C. Lungley—Ships
238 J. B. Alliott and A. H. Sellers—Axle boxes for railway carriages
239 M and O. F. Anketell—Producing manure and fuel from fecal matter
240 W. F. Darlove—Chopping animal or vegetable substances
241 W. J. Coleman—Removing the acidity from sour beer

Dated January 27th, 1870.

242 S Lewin—Stacking hay
243 G. Leach—Shipping and unshipping screw propellers whilst in deep water
244 J. W. Currier—Connecting carriage traces
245 J. H. Kidd—Wheels
246 J. S. James and H. Wilson—Putting together parts of wheels
247 A. D. and J. W. Brown—Cutting curved and irregular forms
248 J. B Smith—Permanent ways
249 W. H. Adcock—Heating water
250 O. C. Moothsin—Umbrellas

Dated January 28th, 1870.

251 W. R. Lake—Lawn mowing machines
252 B. Conti—Scaffolding
253 J. Ricketts—Taps
254 R. Haworth, E. Woock, and J. McCabe—Looms for weaving
255 A. W. G. Weeks, G. Deal, G. Lillywhite, and A. O. Launders—Valves
256 J. E. Stanfield—Carriages
257 J. C Haddan—Registering votes
258 J. Rigby—Axles
259 E S. Caibels and D. Terrace—Manufacture of gas
260 J. Dewar—Treatment of certain substances for food or manure
261 W. R. Lake—Spinning
262 R. H. Dorie—Braking or retarding railway trains
263 G. Thornhill—Hats
264 W. Orr—Ornamenting caps
265 A. M. Clark—Currying leather
266 C. H. Peiman—Hinges

Dated January 29th, 1870.

267 H. J. West—Refrigerating
268 W. White—Wearing apparel
269 A. H. Brandon—Firearms
270 S. W. Mullouey—Seamless articles

Dated January 31st, 1870.

271 J. Hodgson—Railway time tables
272 R. Dick—Covering and insulating telegraph wires
273 A. Paget—Hooks
274 T. Walker Telegraphs
275 T. B. Kay—Carding engines
276 T. W., and E. Lee—Mill bills
277 O. E. Pohl—Ships
278 J. Clark—Collars
279 W. R. Lake—Producing rotary motion
280 E. Brasier—Cleaning and breaking hemp and other fibrous materials
281 C. Mahler—Windmills
282 F. Claudet—Treatment of cupreous ores containing silver
283 J. H Johnson—Sewing machines
284 J. H. Johnson—Engines
285 A. Werkmeister—Liquid meter

Dated February 1st, 1870.

286 J. Bollough—Looms
287 B Latchford—Spur boxes
288 E. Dutasta—Axle cover
289 R. Boyd—Weighing machines
290 T. Markland—Hydro extractors
291 C. W. Fuller—Bottles intended to contain different liquids
292 J. and H. Fisher—Furnaces
293 J. E. H. Gordon—Communicating the direction of the wind
294 W. R. Lake—Needles
295 G. Broadhurst, J. Swindells, and J. Kershaw—India rubber manufactures
296 H. Collins—Safety cage for children
297 A. G. Coes—Wrenches
298 D. Robertson—Carding engines
299 C. Vero—Hats
300 F. R. W. Hedges—Mortising machines

Dated February 2nd, 1870.

301 N. J. Holmes—Inextinguishable lights for marine purposes
302 W. Hartley—Paper bags
303 I. Adams—Effecting the electro deposition of nickel
304 B. Hunt—Watches
305 W. R Lake—Producing carbonic acid
306 C. Kinzler and A Keppler—Propellers
307 J. P. Pritchell—Stoves
308 A. M. Mort—Eliminating disease from the human
309 W. R Lake—Apparatus for revivifying animal charcoal
310 A. W. T. Baker—Nails
311 W. J. Hodge and J. W. Greayer—Obtaining motive power

Dated February 3rd, 1870.

312 W. Shann—Breaking hemp
313 C. Gordon—Firearms
314 B. J. B. Mills—Fans
315 J. H. Johnson—Gas regulators
316 J. Davenport—Riddle for cleansing and assorting potatoes
317 A. V. Newton—Treating iron
318 A. V. Newton—Steel
319 W. R. Lake—Friction clutch
320 W. R. Lake—Spring bed bottoms
321 W. R. Lake—Mowing
322 A. M. Clark—Printing presses

Dated February 4th, 1870.

323 J. Sellers—Effecting calculations
324 J. Thomas—Firearms
325 W. E Gedge—Boxes
326 A. V. Newton—Knitting machines
327 H. E. Newton—Cutting, dressing, and working stone
328 A. La Brun Virloy—Treating ores
329 J. Willis and J. Southall—Cutting leather for the soles of boots
330 T. J. Smith—Chairs

Dated February 5th, 1870.

331 W. Whielden—Kneading machines
332 G. E. Harding—Imparting a reciprocating motion to toothed wheels
333 G. Holmes and J. Winterton—Manufacture of gloves
334 M. Stell—Spinning, twisting, or doubling fibrous substances
335 W. Snaydon—Carriage brakes
336 J. Knowles—Working self acting mules for spinning
337 H. Gardner—Preparing flax for manufacturing purposes
338 W. T. Shaw—Preparing lard
339 L. Meyer—Fastening for ruffles or other articles of dress
340 H. Wittoft—Gas burners
341 F. Sangster—Umbrellas
342 G. Tyler—Securing the ends, bands, or parts of scarfs

Dated February 7th, 1870.

343 G. T. Tietjen—Adjusting shafts to suit the height of animals
344 H. and A Brooks and T. and W. Bestwick—Telegraph wires
345 J. T. Greenfield—Life buoys
346 W. B. Woodbury—Producing surfaces by the aid of photography
347 J. Ramsbottom—Registering the number of games played at billiards
348 H. G. Pendleton—Chain suspender and fastener
349 G. E. Dumont—Treatment of argentiferous leads
350 S. Bremner—Printing machines
351 H. Wedekind—Shaping and treating metallic plates
352 J. Taylor—Ploughing, harrowing, and cultivating land
353 J. Hanson—Breech loading firearms and cartridges
354 H. Hughes—Trimmings, and apparatus connected therewith
355 J. S. Drousfield—Preparing cotton and other fibrous materials
356 B. Walker and J. F. A. Pflaum—Disengaging parts of machinery

Dated February 8th, 1870.

357 J. Kenyon—Pickers for looms
358 J. Ward and J Bowing—Preparing and drying yeast
359 H. Bond and J. Riley—Counterpanes and such like fabrics
360 D. Rorison and R. G. Finlay—Looms for weaving
361 S. W. Thomas—Bicycles
362 C. D Abel—Taking soundings at sea
363 A. Field and E Badger—Velocipedes
364 G. W. Wigner—Treatment and purification of sewage
365 E Cruger—Re utilising caustic soda lye
366 R. Edwards—Steam cultivation
367 H. Lue—Waterproofing
368 A. A. Common—Regulating the supply of water to waterclosets
369 J. Pinney—Organs
370 W. Davison and W. Richards—Preventing the fouling of ships' bottoms

Dated February 9th, 1870.

371 A. B. Childs—Cleaning wheat and other kinds of grain
372 R. C. Cutting and A. Mason—Marine and other compasses
373 T. A. Warrington—Presses
374 J. Tenwick—Holding fingers used in mowing machines
375 C. Crossley, R. Whipp, and T. Crossley—Size
376 C. Bardy—Preparing and obtaining colouring matters
377 R Peacock and E. Wilson—Disintegrating and crushing mill
378 J. Haley—Illuminated rotary advertising apparatus
379 R. Punshon—Securing boats on decks of ships without lashing
380 J. T. Greenfield—Side arm for clearing the rifling of ordnances
381 F. Prince—Preventing fog signals being passed on railways without the knowledge of the driver in charge of the train
382 T. J Smith—Guiding the movements of torpedo boats
383 A. and H. Foley—Production of photographic pictures on wood
384 W. Bevitt and T. Strickland—Brakes
385 C. Baylis—Preventing impersonation
386 J. Petrie—Drying wool
387 J. M. Stanley and W. Atkins—Generating steam
388 H. T. Humphreys—Railways

Dated February 10th 1870.

389 C. and F. Pontifex and A. Sherwood—Pressing spent grains
390 W Hadfield—Looms
391 G Eguillon—Reducing the friction of pivots turning on oscillating levers
392 W. Houghton and J. Bapty—Dressing warps of wool
393 J. and W. Thomson—Ventilating chimneys and apartments
394 J. C. Wilson—Shearing sheep
395 W. R. Lake—Production of fringe upon woven fabrics
396 W. E Gedge—Currying leather
397 W. R. Lake—Printing machines
398 W. M. Mason and T. Lockerbie—Utilising water pressure
399 W. Swain—Cricketer's battery
400 F T. Ferguson—Jugs
401 W. R. Lake—Looms
402 A. Turner—Carpets

Dated February 11th, 1870.

403 J. Imray—Subaqueous communication
404 M. Macdermott and A. D. Williams—Augers and drills
405 D. Dalglish—Looms
409 A. B. Brown—Transporting heavy objects from one place to another
407 W. R. Lake—Spring seats
408 J. Thompson—Spindles
409 J. Story—Submarine telegraph cables
410 E. Stott, A Ogden, and W. C. Stafford—Preparing cotton
411 J. Smart—Slide valves
412 J. W. Dixon and J. Bates—Filing
413 I. Nasch and C. Grimme—Sewing machines to produce button hole hems
414 R. Chanony—Playing cards
415 W. R Lake—Drying sugar
416 W. E. Newton—Bolting or sifting flour and meal
417 W. Spence—Polishing yarns

Dated February 12th, 1870.

418 J. H. P. Colson—Portable frame for playing billiards on ordinary tables
419 B. Looker—Horticultural structures for growing seed
420 J. Brown—Utilisation of waste made in wet flax spinning
421 J. and J. Botterill—Consuming smoke
422 J. Morrison—Gas stoves
423 M. Brown—Carpets
424 A. Prince—Generating gas from petroleum and such like articles
425 W. T. Whiteman—Printing dates on railway tickets

Dated February 14th, 1870.

426 O. C. Evans—Digging machinery
427 J. Flear—Clipping horses
428 E. W. Forrell—Bolt or fastening for doors and windows
429 T. T Lingard—Preparing stone
430 A. Fryer—Preserving animal and vegetable substances
431 W. Larking—Fire escapes
432 W. Tasker—Elevating hay and other agricultural produce
433 W. Whieldon and J. Beck—Valves
434 F. T. Ferguson—Combined hammer, nail puller screwdriver, and rule

Dated February 15th, 1870.

435 R. F. Fairlie—Stuffing boxes
436 J and W. Weems—Metal pipes
437 H. B Barlow—Jewel boxes
438 H B. Barlow—Bottle cases
439 A. Neill—Cutting wood
440 A. H. de Villeneuve—Obtaining and applying motive power
441 G. Lieberknecht—Disentangling hairs
442 H. Dupland—System of coatings against dampness
443 H. Collins and R. T. Hedges—Exhibition of advertisements
445 E. A. Parnell—Conveying sulphuric and other acids
446 B. Blackburn—Locomotion
447 E. W. Knowles—Stamping

Dated February 16th, 1870.

448 W. Smith—Looms
449 T. W. Rammell—Boilers
450 I. Mason—Measuring liquids
451 A. Stewart—Railway wrappers
452 W. M. Scott—Firearms
453 J. Abraham—Breech loading firearms and in percussion caps
454 L. Hill—Locomotives
455 T and H. W. Whitehead—Preparing wool and other substances
456 J. Banrehr—Artificial fuel
457 E L. Roeleus—Indicating apparatus for mining purposes
458 G. Twigg—Shearing
459 W. R. Lake—Vegetable parchment or parchment paper
460 J. Dawson and N. G. Lambert—Glass and other furnaces

Dated February 17th, 1870.

461 B. Hunt—Mowing machines
462 W. B. Moore—Sewing machines
463 S. Leoni—Apparatus for beating and lighting by gas
464 L. Lucon, and Z. P. Kern—Pumps
465 J. MacNeill—Soap
466 R F. Drury—Spanners
467 C. D. Austin—Lubricators
468 W. Brass and P. Hackworth—Dressing and working stone
469 J. Wulmsley and T. Roberts—Ornamenting cloths
470 R. A. Leigh—Carding wool
471 G. Battumelli—Lamps
472 C. T. Balonchard and L. A. Damsrs—Cleaning grain
473 R. Duerre—Velocipedes
474 J. H. Johnson—Lighting
475 A. Millar—Marking linen and in marking ink for the same
476 W. R. Lake—Determining the distance of celestial bodies

Dated February 18th, 1870.

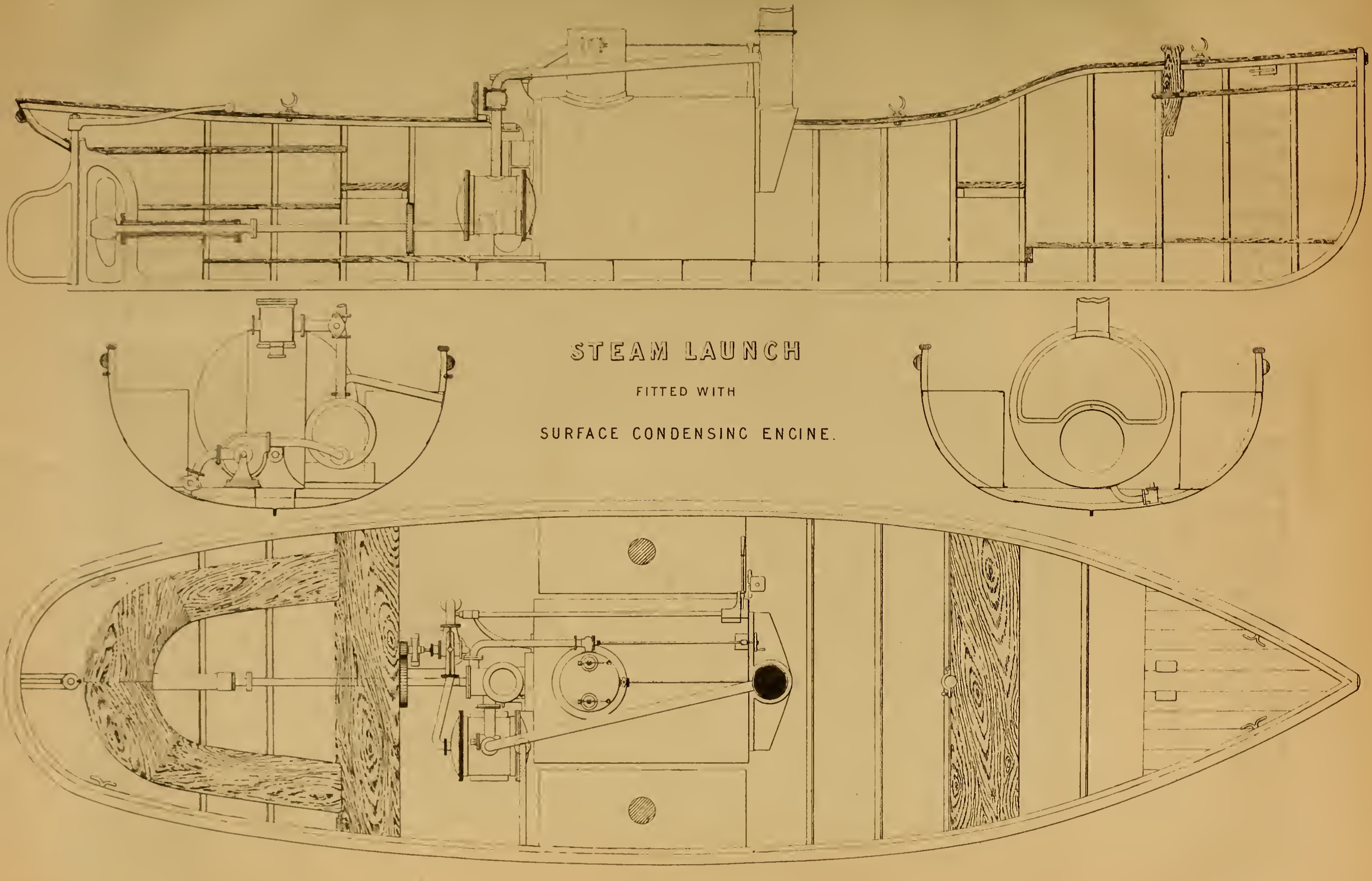
477 E. Lord—Spinning
478 C. A. Rober and C. M. Gallet—Stoppers for bottles
478 L. E. Peyrounil—Transparent covers for cotton, &c.
480 C. Beaton—Preventing the bursting of water pipes
481 R. Hunt—Storing liquids
482 B. Baruard—Beds for infants
483 S. W. Clark and W. R. Sykes—Hand signal and other lamps
484 B. Chafer—Billiard tables
485 I. Baggs—Ammonia
486 T. Rossell—Auxiliary screw propellers to sailing vessels
487 C. Bartholomew—Getting coal
488 J. Brown—Converting the waste of hemp
489 J. L. Norton—Embroidering

Dated February 19th, 1870.

490 G. Jones—Consumption of smoke and saving of fuel
491 T. Reid—Ploughing
492 E. Hill—Engine turning
493 M. Wilson—Bird cages
494 R. Lakin and J. Bayley—Spinning cotton and other fibrous materials
495 M. H. Nicholson—Knife handles
496 C. Thomas—Soap frames
497 F. O. Camroux and G. Oliver—Breaking stone &c.
498 J. H. Johnson—Oxygen gas
499 J. Hammond—Washing clothes
500 A. Jeffeis—Stamping soles of boots

Dated February 21st, 1870.

501 G. Newsum—Letterpress printing
502 S. Osborn—Hardening knives
503 E. Maw—Apparatus for manuring and irrigating land
504 W. E. Heath—Gas governors
505 S. Hulme—Removing paint from wood
506 J. Leopard—Treating sewage
507 J. Fournier—Substitute for gunpowder
508 T. J. Smith—Shearing horses
509 J. Richards—Preventing fraud in cheques and similar documents
510 F C. Hills—Gas
511 W. R. Lake—Pneumatic engine



W Smith C.E dirs

THE ARTIZAN.

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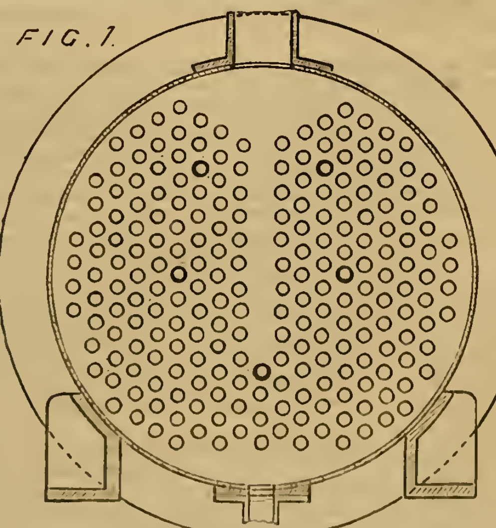
STEAM LAUNCH FITTED WITH HIGH PRESSURE CONDENSING ENGINE.

(*Illustrated by Plate* 359).

In The Artizan of last February we gave a Plate (357), containing various designs for high-pressure boilers suitable for yachts or other small craft, in the hope that they might be of assistance to intending purchasers or builders. We now have the pleasure of placing before our readers an illustration of a high-pressure condensing engine suitable for the same purpose, and which may therefore be considered as a sequel to it. It will be remembered that in the description which accompanied the plate, the necessity for using clean water with several of the boilers there illustrated was insisted upon. As, however, owners of such steam yachts cannot be expected to confine themselves to travelling in clean or even in fresh water, we illustrate in the accompanying Plate (359), a simple design for a surface condenser attached to a small high-pressure engine, by means of which the requisite fresh water may be obtained. It is, we believe, considered by all experienced engineers to be an acknowledged fact, and one which has been frequently insisted upon in these columns, that high-pressure and salt water will not agree, and in large sea-going vessels, surface condensers are invariably fitted to engines designed for working with high-pressure steam. It has, however, been very generally assumed that for small boats, such as those now under consideration, this system would be inapplicable, and it must be acknowledged that it has several apparent disadvantages. Thus, it is said a surface condenser entails extra space for the machinery, which can be ill afforded in a small boat; the increase of cost which it entails is also very considerable, and, above all, the extra amount of knowledge required to manage the engines is a great objection. Now we think those inconveniences are very much overrated, and, moreover, that they are far more than counterbalanced by the undoubted advantages obtained by its adoption. The objection to a surface condenser upon the ground of it occupying too much space will, we think, be satisfactorily disposed of upon referring to the Plate (359), where a surface condenser is shown fitted to an engine with a 9-in. cylinder, and in which case it will be seen that it does not increase the engine space by more than about a foot in length. The objection to a surface condenser on account of its cost is apparently more valid, but when we take into account the saving effected in the consumption of coal, and in the cost of repairs to the boiler, together with the annoyance of the delay incurred during those repairs, not to mention the chance of a break-down in the boilers at a place where there are no means for repairing it, it will, we think, be conceded that the extra amount expended in the first cost of the machinery has not been wasted. As regards the extra amount of skill required to work an engine of this description, we think this objection will be found to be chiefly imaginary, for upon reference to the plate it is evident that there are no more valves, &c., to look after than if there were no condenser; the only extra cock shown being simply for the purpose of shutting off the communication between the condenser and the engine, and at the same time allowing the blast to go into the funnel so as to work as the ordinary high-pressure engine.

Amongst the numerous advantages connected with this system the most important is of course, the enabling the boat to travel through salt or dirty water without any chance of injury to the boiler. Another very important advantage already alluded to, is the economy of fuel, the saving being effected by feeding with hot water, and the entire freedom from the necessity of blowing off. But there are also several minor inconveniences and annoyances well known to all who are accustomed to travel in yachts fitted with non-condensing engines, which are entirely obviated by the use of the condenser. Thus it is well known that with non-condensing engines, these small boilers are liable to prime at any moment from the unavoidable variation in the amount of feed, and are almost certain to do so when any considerable change in the state of the feed water occurs, consequently the passengers are constantly in a not ill-founded state of alarm as to their appearance at the end of their journey. Another unceasing cause of annoyance inherent to all boats with non-condensing engines, though of varying intensity according to their different designs, is the noise caused by the exhaust; the annoyance in this case not being confined to the passengers, but in many cases including innocent outsiders for a considerable distance from the boat. The perfect regularity of the feed obtained by the surface condensers enables the steam to be kept much more uniform and with less trouble, and obviates the necessity of constantly altering the feed pump. The boat and engines illustrated in our Plate (359) were designed and built by Messrs. Jackson and Watkins, Canal Ironworks, Limehouse, and besides affording an excellent example of a simple and effective arrangement, it affords a very good illustration of the method of applying a surface condenser to an existing high-pressure engine. The boat is 35ft. long, 8ft. 9in. beam, and 4ft. 4in. deep. These dimensions though well suited to the purposes for which the boat was intended, appear to be scarcely well adapted for speed; another 10ft. added to the length would seem to be advantageous. The condenser is illustrated in the

FIG. 1.



accompanying engraving, Fig. 1 being a transverse section, and Fig. 2 a longitudinal section. It contains 220 tubes, 18in. long, and ¾in., outside diameter; the inlet and outlet pipes for the circulating water being 2in. in diameter. The boiler is similar in design to that shown in Fig. 2, Plate 357, in The Artizan of February; the shell being 5ft. 6in. in length, and 4ft. 2in. in diameter. The fire-grate surface is 5 sq. ft., and there are 24 tubes 2¼in, outside diameter, and 4ft. long. The cylinder, which is 9in. in diameter, and 8in. stroke, cutting off at ⅝, drives a screw 2ft. 8in. in diameter, 4ft. pitch, at the rate of 254 revolutions with 58lbs. pressure in the boiler, the speed of the boat averaging about $7\frac{3}{4}$ knots per hour. The coal bunkers are made water-tight, either to carry water or to act as air chambers. It is found after considerable

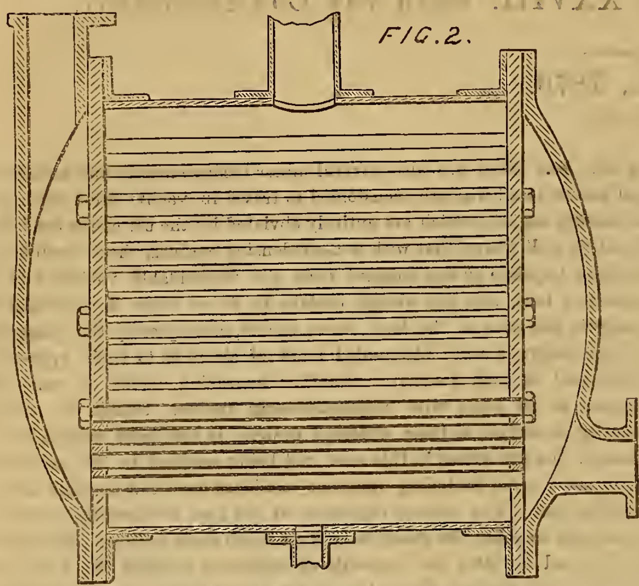


FIG. 2.

experience, that in addition to the great saving in fuel already alluded to, that the boat travels rather faster when condensing than when the blast is turned into the funnel, and the engine made non-condensing, there being plenty of steam without the use of any blast whatever.

NEW YORK AND BROOKLYN SUSPENSION BRIDGE.

The following account of this important engineering work is condensed from an interesting description contained in the *Manufacturer and Builder*:—

New York and Brooklyn are in reality only one city, notwithstanding they bear two different names and have two different city governments. They belong as much together as the two halves of London on both sides of the Thames, or the two halves of Paris on both sides of the Seine, or the two halves of Rome on both sides of the Tiber. The only difference is, that the river separating the larger half of New York from its smaller half is a deep, wide, and swift-running stream, while the Thames, Seine, and Tiber are comparatively shallow, narrow, and sluggish. Indeed, the amount of water passing through the East River at every tide is enormous; the velocity of the current, always great, has increased with the improvement of the Hell gate channel; and when all the obstructions shall have been removed from that channel, the current will be still more inconvenient, chiefly to the steam ferry boats, which, to the number of twenty-five, by seven different ferries, now transport weekly one million persons across this river, between New York and old Brooklyn, not to speak of the eastern district of Brooklyn, formerly called Williamsburg, which is connected with New York city by means of seven other steam ferries, all crossing the same river.

Among the different plans for more perfect communication, a system of solid dams was suggested, with streets and warehouses on the top, closing the East River to navigation entirely, and changing it into enormous docks or basins, provided with locks. This plan was elaborated by different persons in a great variety of shapes. A tunnel has been proposed, in imitation of the tunnel under the Thames; or the Chicago subfluvial tunnels; or the one now to be made under the Detroit River. But the circumstances are very different; the depth of the Thames is only some twenty feet, and that of the Detroit River forty; and both flow on a bed of uniform clay, easily cut and supported with water-tight brick masonry. The East River, on the other hand, is sixty feet deep in the channel; and the bed is composed of rock, interrupted by cracks filled with earth and boulders. This heterogeneity of the substratum would present great difficulties; and, although the tunnel can not be pronounced impossible, the expense of its construction would be very great.

The plan of a bridge is preferred to those of a causeway and a tunnel and considered at the present day the most desirable and practicable; and, as the depth of the water and the requirements of navigation preclude the building of arches on piers, nothing is left but the construction of a suspension bridge. It is an old saying, almost a proverb, that when by a concourse of circumstances a man is really wanted, be will be found. So it was in this case. America possessed an engineer, Mr. John A. Roebling, of Trenton, N.J., who had made the building of suspension-bridges, a speciality; and had successfully constructed two of the boldest bridges of this kind in the world, namely, that at Niagara Falls and that at Cincinnati, which is now the largest in existence, but will be far surpassed in dimensions by the East River suspension-bridge. To give an idea of its dimensions, we will only say that, including the approaches, it will be over one mile long; and that the bottom will be 130ft., in clear height, over the channel of the river. Mr. Roebling was spared long enough to complete the plans for this colossal work, the execution of which is now intrusted to the worthy hands of his son.

The bridge has only two piers, situated on the shores, and thus not in any way obstructing navigation. They are 1,620ft. apart and 280ft. high. The base of these piers, at the water-line, is 134ft. long and 56ft. wide; of their height, 130ft. is below the floor and 150 above it, not including balustrade and ornamental blocks. In each pier are two arches for entrances to the bridge; each archway, being 32ft. wide, gives passage to a railroad track, a carriage way, and a sidewalk. These openings, or archways, are intended to be 120ft. high. The piers will be built wholly of granite, and hollow; each will contain over 900,000 cubic feet of stone, and weigh over 70,000 tons. The bridge will weigh 3,600 tons; its maximum transitory weight by crowds of people, railway trains, carriages, and horses being 1,400 tons, gives together 5,000 tons. As the base of each pier is nearly 5,000 square feet, there is a weight of about 15 tons per foot, which cannot be safely constructed without enlarging the foundation considerably. At the lower part of the foundation, therefore, the surface will be 17,000 square feet, reducing the pressure form 15 tons to a little over 4 tons per square foot, which is perfectly safe, especially in view of the considerable depth to which the foundations will be laid, the nature of the compact, gravelly sand on the Brooklyn side, and the rock which probably will be reached on the New York side.

The whole bridge will be supported by four cables, consisting of parallel steel wire, stretched in a bundle nearly one foot thick. These cables are anchored in solid walls, 1,337ft. from the pier on the New York side, and 837ft. from the pier on the Brooklyn side. The real span of the suspension-bridge, from anchor-wall to anchor-wall, is thus 1,337+1,620+837, or 3,794ft. The approaches beyond these points are of arched masonry, thrown, like the half-spans between anchorage and piers, over houses and streets.

Each of the four cables enters the anchor walls through the masonry to a distance of twenty feet, where they connect with the anchor-chains, composed of ten links, each 12ft. or more in length, together measuring 130ft., and forming a downward curve of a quarter of a circle, in order to convert a portion of the tension into downward pressure—a plan always followed in the anchorage of suspension-bridges. The tension, or pull, of each of these four cables on the anchorage will be 5,000 tons, which is only about one tenth of the breaking strain of the structure.

The cables have, however, not to support the whole bridge, It is also secured by straight stays, running from the top of each pier toward the bottom of the bridge. Mr. Roebling asserts that the bridge would not fall even if the cables were removed, the stays being sufficient to hold it—only it would sag in the middle. The cables have, therefore, only to sustain a portion of the weight, and to give stiffness to the bridge, so that it will not be swayed by heavy gales. A simple arrangement of the cables increases this stiffness against side pressure. The outside cables are much farther apart at the piers than the width of the bridge, and approach each other; while with the two middle cables the reverse is the case. They are near together at the piers, where they pass over the middle between the two arches, and widen toward the middle of the bridge.

The bridge will commence in New York City at the City Hall Park, at the head of Chatham-street. Slowly rising $3\frac{1}{2}$ft. in 100, it will cross William-street and Franklin-square, so that no interruption of street travel will result. It will be supported by arches, girders, and trusses, till it arrives at the anchorage of the chains, 90ft. above high tide, located in the block bounded by Cherry, Water, and Dover-streets, where the suspension commences; and the whole structure runs over all the houses to the pier at the river side, a distance of 1,337ft. Here the full sweep of the cables, passing over the top of the piers, 260ft. high, descends 130ft. below that point, and rises to the same height on the Brooklyn pier, to descend to the Brooklyn anchorage, situated in James-street; and, beyond that, by an archway of masonry and trusses, to extend to the junction of Fulton and Sand-streets, almost on a level with Brooklyn Heights.

The New York pier will be situated where now a dilapidated pier, known as No. 29, is located; that of Brooklyn, in the east slip of the Fulton ferry. The work on the latter was commenced on Monday, January 3rd, 1870; and has since been continued by means of dredging-machines, &c., preparatory to sinking a colossal caisson, which is being built at Greenpoint, and has advanced considerably toward completion. There being no suitable rock foundation found on the Brooklyn shore, the caisson itself will form part of the foundation. The system adopted for constructing the piers is upon the principle of the pneumatic pile, which is usually a tubular pile or cylinder of large dimensions, forced down by atmospheric pressure. In this case, however, the atmospheric pressure is assisted by the continual excavation of material beneath the mass.

The caisson or chamber within which the work of excavation will be carried on, is rectangular in shape, 168ft. long and 102ft. wide on the outside, and about 15ft. high. The sides are wedge-shaped in section, the lower edge being eight inches, and the upper eight feet eight inches thick. The roof resting on these sides is five feet thick, leaving a working chamber (the dimensions of roof and sides being allowed for) 166 by 98ft. in ground area, and 9ft. in height. The whole is constructed of yellow-pine timber, a foot square; the seams are payed with a vegetable tar, to render them impervious to water; and between the outside layers of timber is a sheathing of tin, between two of felt, intended to prevent air from leaking through. As the sharp lower edges are intended to facilitate the sinking of the caisson, they are made very strong. The first course of timber is oak; to this is bolted a cast-iron shoe, eight inches wide, and oval on its face, being three inches thick in the centre. Around the shoe is placed an armour of boiler-plate, extending three feet above, on both sides of the wall, the whole being strengthened by heavy interior angle-irons. Especial pains are taken to prevent the corners at the bottom from "spreading" under the great pressure to which they will be subjected. At each corner, in the second course, is inserted a knee of hard wood timber, extending twenty feet each way. The timbers of the caisson are all bolted together vertically, horizontally, and diagonally, with $1\frac{1}{4}$in. bolts, varying in length from two to 7ft. The bolts are, on an average, 18in.—none more than 2ft. 8in.—apart throughout the whole structure; and the heads and nuts are made air-tight by rubber washers.

As this huge frame is sunk to its desired position, 30ft. below low tide, additional courses of timber will be laid on the top, to the height of 15ft., and filled in with concrete; and when the whole mass has become fixed in its final resting place, the tower will be built on the solid foundation thus obtained.

Six shafts, lined with half-inch boiler-plate, pass through the roof of the caisson. The two outside ones are rectangular, and 6ft. 6in. by 7ft. in size. These are the water-shafts, in which the water collecting in the caisson will rise by the atmospheric pressure to the height of the tide outside. Next to these are the two man-shafts or supply-shafts, circular in form. Through these the workmen will pass, and the earth be hoisted. The last pair are the air-shafts, also circular, and 42in. in diameter. The shafts are made in couples, both for convenience and for safety. Through the air-shafts large air-pumps will force air into the caisson, expelling the water, and enabling the workmen to descend and work upon the bottom. The earth excavated will be deposited around the square water-shafts; and a dredging-machine will lift the mud and dump it into barges. As the excavations progress, the caisson will sink. During this operation, it is to be hoped that the edges will come upon no large boulders. It is of the utmost importance that this heavy structure, which will not be very manageable when it is once under water, shall move downward with quiet uniformity; and fortunately there is no reason to expect in the sand of the Brooklyn shore any serious obstacles to this part of the work. Gas is to be introduced for lighting the caisson. The following figures will give to some readers a better notion of the size and importance of this construction: length of caisson, 168ft.; width, 102ft.; height, 15ft.; height including superincumbent timber and concrete, 30ft.; timber in caisson, 1,500,000ft., (105,000 cubic feet); weight of caisson, 2,500 to 3,000 tons; wrought-iron employed in bolts, angle-irons, and plates, 100 tons; lumber in launching-frames and ways, 127,000ft.

PATENT LAW.

The Bovill Litigation.

(*Continued from page 69.*)

When this decision in Bovill *v.* Smith was pronounced, several millers against whom Chancery suits were commenced, were advised to ask the Court to allow juries to be summoned for the purpose of trying the cases. An application of this nature was made to the Master of the Rolls in the suit of Bovill *v.* Hitchcock, but was refused. The question of the right of a defendant in a Chancery suit to submit his evidence against the validity of a patent was a very important one, and an appeal was brought against Lord Romilly's decision, and was heard before Lord Cairns, then Lord Justice, on the 14th January, 1868, when the following judgment was delivered :—

"This appeal is rested on two grounds—the first being, that as before the course of the Court of Chancery was altered, so as to throw upon the Court the duty of deciding questions which, according to its former course, were sent to be tried at law, a question of this nature would have been tried at law, so now either party has a right to insist on its being so tried. I cannot accede to this argument. The effect of the Acts is to impose on the Court the duty of deciding these questions, and, in the absence of any direction to the contrary in the Acts, the Court must try them according to its ordinary course of practice. If the Court thinks it best that a question should be tried before a jury, a jury can be had; but if, in the opinion of the Court, a trial without a jury is preferable, neither party can claim a jury as a matter of right. It is a fallacy to say that under the old practice the Court required a legal question to be tried by jury. What it required was the judgment of a Court of Common Law. In most cases it was a necessary incident to proceedings at law that there should be the verdict of a jury before judgment; but these cases were sent to law, not that they might be tried by jury, but because this Court had no jurisdiction to decide upon legal rights.

"Secondly, it was urged that a trial might be had before a jury because the Master of the Rolls, in a former litigation between the present plaintiff and another party, expressed a strong opinion in favour of the patentee, as regarded the questions then in dispute. If that has any bearing on the present case, it would rather go to show that the trial ought to be before another judge than before the Master of the Rolls with a jury. His lordship, after having had his former expressions called to his attention, stated it to be his opinion that this case could be conveniently and properly tried before him, and more conveniently without than with a jury; and it has not been urged that there was anything in the nature of the case to make it especially proper to be tried by a jury. With all respect for that mode of trial, I think that many patent cases can be disposed of by a judge much more satisfactorily than by a jury; and I should be exceedingly disinclined to interfere with the discretion of a judge as to the mode in which a particular case can be most advantageously tried in his court."

The defendant then made terms with Mr. Bovill.

The suit of Bovill *v.* Bird came before the Rolls Court on an application for an injunction to restrain Mr. Bird from bringing on for argument a demurrer in an action brought against him in the Queen's Bench for infringing the patent. The demurrer was a submission by Mr. Bovill that some of the grounds of defence pleaded by Mr. Bird were insufficient in law. It was probably thought incongruous to ask the Court of Chancery to prevent a defendant in an action at law taking the judgment of the court of law upon the questions of law raised in the action, and Mr. Bovill, without having the motion for the injunction argued, cut the knot by discontinuing the action, paying the defendant's costs.

Mr. Bird, however, had as strong an aversion to the Court of Chancery as Mr. Bovill had to the Court of Queen's Bench, and he compromised the Chancery suit.

As an introduction to the second trial of the issues in Bovill *v.* Goodier it is necessary to state that Mr. Goodier had described in his answer to the Bill in Chancery a creeper in the horizontal trunk into which the exhaust pipes from his mill-stone cases had been connected before he adopted Blake and Lee's improvement of having a fan on the mill-stone spindle. The creeper was to serve the same purpose as the "monkey," or damper, which in many mills is drawn from end to end of this air trunk to clear out the deposit of flour dust. In Mr. Bovill's affidavit, he referred to this description and to Mr. Goodier's model of those arrangements, and he made the following very important statements :—

"I have read the defendant's answer filed in this cause on 12th January, 1865, and I say that the apparatus and process described by him in the 11th paragraph of his said answer, and purporting to be, save as regards the stive room, the process so as aforesaid, shewn by model No. 1, is an infringement of my patent. In order to attain the object stated by the defendant in the 10th paragraph of the said answer, for which he desired to apply an exhaust, viz., 'to cool and dry the meal or flour before it reached the meal trough, and also to free the meal from the stive or dust which resulted from the process theretofore in use'; the defendant did in fact, adopt the very means described in my said specification to carry out the same, and which he now alleges to have been his own discovery, made in 1854. The details of the defendant's machinery were in all respects similar to those employed by me in numerous mills where my patent had been put up, save as regards the particular character of the stive room, and save that an endless screw for clearing out the stive, or fine dust, deposited in the horizontal exhaust pipe, was applied by him, instead of the simpler apparatus adopted by me of a wooden piston moved by a cord, for the purpose of being occasionally drawn from one end of the pipe to the other to clean out the dust or flour from the trunk."

"The mode in which these very considerable inconveniences are alleged by the defendant to have been got rid of by applying an exhaust fan and producing an action thus stated by him in the 11th paragraph of the said answer, 'The revolution of the exhaust fan caused an upward draught of cold air which, entering the said twelve exhaust pipes, or portions of exhaust pipes, at the orifices thereof, just above the meal trough, ascended and made its way through the before described other pipes, or portions of pipe, and finally made its exit into the open air; the before-mentioned exhaust had the effect of cooling and drying the meal or flour in its descent from the points where the delivery spouts entered the lower portions of the exhaust pipes, or portions of exhaust pipe as aforesaid, and the further effect of carrying upwards a considerable portion of the stive or dust occasioned by the grinding process.' I say that such action and process so used and described by the defendant, is in fact, and relates only to sucking away the plenum of warm dusty air forced through the stones, and not to employing a sufficient exhausting power to induce a current of air between the millstones, without a blast, as described in the specification of my said patent, page 8, lines 15 to 22, and I make such statement upon various grounds, and amongst others the following, Had the defendant used a too powerful exhaust, overrunning the blast, and exhausting more than the plenum there would have been a strong current of air rushing up the meal spout and such last-mentioned current would have held up the meal and prevented it descending the spout, and would have stopped the working of the mill by the meal accumulating in the mill stone cases, around the stones, and choking them to such an extent that the meal could not issue from between the grinding surfaces, and further, a too-powerful exhaust would have drawn up a large quantity of meal into the exhausting machine, and have blown it out and created excessive dust and waste in the mill, and would have drawn the air so rapidly through the pipes that no lodgment or deposit of stive in the said pipes, as mentioned in the 11th paragraph of the defendant's said answer, could have taken place, but the same would have been blown out of the fan. Had the exhaust been too weak, the stive and dust would have descended the meal spout with the meal, and been delivered or blown about the mill; and the effect stated by the defendant in the 6th paragraph of his said answer, as resulting from the use of the old process, would have been produced. The defendant must have employed the exhaust of the plenum, since there was just sufficient exhaust to create an upward current through the meal spout, analogous to the draft of an ordinary chimney, as hereinbefore mentioned, and to carry off from the millstone cases the warm dusty air in manner hereinbefore mentioned."

The second trial occupied eight days, and came to a close on the 11th Feb., 1868, when Mr. Justice Byles thus summed up:—

"Mr. Justice Byles, Gentlemen:—In this case, George Hinton Bovill is the plaintiff, and James Goodier is the defendant. It is an issue directed by the Master of the Rolls to you, to try whether that part of the invention comprised in letters patent granted to him, and comprised in the specification, be good or not when altered by the disclaimer. The first question is 'Whether [*that part of the invention described*] in the said specification as altered by disclaimer [*as*] the fixing the top stone and causing currents of air, either by exhaustion or pressure, to pass between the grinding surfaces of the millstones when the top stone is so fixed, and in the introduction of ventilating machinery in the stones described in the said specification [*as the first part of the invention*] was a new invention at the time of the patent?' Secondly, 'Whether that part of the said invention which is stated to consist in exhausting the dusty air when the same has been blown through the grinding surfaces of the millstones from the stone cases or chamber receiving the meal, described in the said specification was new at the date of the letters patent?' The third is, 'Whether that part of the invention which is said to consist in the passing the dust or stive caused in the process of grinding through suitable porous fabrics, by which the flour is filtered from the air, described in the specification as altered as aforesaid was a new invention at the date of the letters patent?' Fourthly, 'Whether the combination of the three said several parts, described in the specification so altered, was new at the date of the specification?' In effect, gentlemen, the issue is whether these three claims, or either, and which of them, have been anticipated?

Now, gentlemen, before I call your attention very particularly—which I must do before I go further—to this specification, allow me to distinguish (for that you must bear in mind) between questions of law and questions of fact. You have had the advantage of hearing counsel on each side—I allude to my learned friends Mr. Webster and Mr. Grove; you have had the advantage of hearing on each side in this case the two gentlemen at the Bar of England who are best acquainted with Patent Law. I confess that I have received very great benefit and very great instruction from listening to them. I always listen very carefully to counsel, and I believe that everything that can be said has been said, both as to the law and as to the facts of the case. Therefore, the time has not been wasted. I think no time has been wasted. The fulness with which you have heard the discussion, and the patience with which you have listened to both sides, will very considerably abbreviate the observations that I shall have to trouble you with. But first, as I said, let us distinguish between questions of law and questions of fact. Questions of law are for the Court—for the presiding judge, who must be right at his peril. I do not incur much peril here, because the way has been traced out to me by the three learned judges who have preceded me. If the judge is wrong—nay, even if the Master of the Rolls were wrong, or my brother Willes was wrong, there is a resort to a superior tribunal, because what the judge has said is in white and black, and you can appeal against it and correct it; but as the judge is bound to leave questions of fact to the jury, so the jury are bound to leave questions of law to the judge. I shall tell you, for the purposes of to-day, what you must, as I conceive, take to be the law. But with respect to facts, if you discover in my mind any indication of opinion on the one side or the other I request you to discard it. I shall assist you as far as I can, but as the Court claims to decide the law of the case, so the jury, and they only, are to decide the facts. The Master of the Rolls might have decided, if he thought fit, the questions of fact. He did not do so. He sent it for you to decide; and I am quite certain he sent it to a tribunal whose minds are pure, and who will not have made up their minds at all until the case is at an end.

Now, gentlemen, amongst the questions of law is the construction to be placed upon a written instrument. As a general rule—there may be some exceptions, of which this is not one—construction of a written document is for the judge or the Court. If it be a will, the jury are not to say what the will means. With great deference to them, they have not spent their lives in the reading and construing of such instruments. It is for the Court. If an irregular promissory note or bill of exchange is made, what the effect of it is a question of law for the Court, not of fact for the jury. So in construing the specification of a patent, and saying what it means, the question of construction is for the judge. He will tell the jury what the patent means, at his peril, as I said before. The jury will then apply their minds to it, and answer the questions of fact which are submitted for their consideration. Another observation I will make to you. Utility is not here in question. However useful Mr. Bovill's patent may be, if it is anticipated it comes to nothing. On the other hand, where you find that the utility which is said to result from the patent is very great and striking, and that the utility did not exist before, the utility may, as has been contended at the bar not without some show of reason, reflect light upon the novelty of the patent. But, further than that, utility has nothing to do with this question. You will not give Mr. Bovill your verdict because it is a useful patent. Another matter I beg to state. I have already alluded to it, and the learned counsel, Mr. Grove, has also stated the same thing. If a patentee claims too much and does not disclaim it, and a bad claim remains, not only that claim, but the whole patent, is bad. Now Mr. Bovill has reviewed or recensed the patent. He has gone through it once with his disclaimer, and he has, as he now contends, and he now says he did, eliminated every doubtful claim, and left it as it now stands; but if one of those three claims is bad, the whole patent has been bad from the beginning. I say that, that you may see what a vast stake is before you, because it turns out, upon this evidence, that the sum in dispute is between £100,000 and £200,000. That is dependent upon the breadth of your mouth. Another observation I beg to make to make to you, which you will find useful as you go along if you thoroughly understand, is this—it is very essential to be brought before you, perfectly familiar to my learned friends at the Bar, but possibly not so familiar to you—a combination may be the subject of a patent, often is—generally is. Although in this combination all the ingredients but one—I say, first of all, but one—are old, yet if the introduction of that ingredient in connection with the others be useful and novel there may be a new patent for the combination although three of the things are old. So it happens in many patents, if the ingredients are all old, yet if a novel and useful combination is introduced by the patentee there may be a good patent for the combination. In saying this, I dare say I am only reminding you, but it is well that you should be reminded, of what the law is before we address ourselves to the construction of the patent which is the first thing to which I shall invite your attention. Another rule of law, which you must bear in mind, is this—there may have been a great many experiments in many cases before the real thing was found out, nay sometimes what turns out to be the real thing has often been used but only by way of experiment and then given up. That is not an anticipation of a patent. Mere experiment or unsuccessful user are not anticipations of a patent. A man must have brought his invention, or his invention of a combination, to a successful issue so that the thing can be done and it must be done not as a mere experiment.

"Now, gentlemen, with those previous observations upon the patent we will address ourselves now to what this document means. I do not know whether any of you have had the patent before you. If not I will direct that a copy or copies be laid before you when you retire to consider your verdict. And first I must premise that this patent—that is the first judgment of the law upon this patent—has been before many tribunals. It was granted in the year 1849, It was renewed for five years from the year 1863, and will expire if I am right next June. It has but a few months to live, but great issues depend upon it from what has already passed. This patent, I tell you as matter of law, is good upon the face of it. There is no fault on the face of it. It has been through many tribunals, and has been nearly through 19 years of its existence, and it has stood shot from that time to this. You must take it from me that the patent on the face of it, subject to questions of fact whether it has been anticipated, is a perfectly good patent. To express myself more correctly, the specification is good upon the face of it.

"Now, gentlemen, I do not think it necessary to read this patent over to you. If I did I should over-lay with a good deal of extraneous matter the few observations that I have to make upon it. The best course I can adopt is to take you to the first claim at first. You have heard enough about the patent to know the general nature of it. Now the first claim is this: 'Fixing the top stone and causing currents of air either by exhaustion or pressure to pass between the grinding surfaces of millstones when the top stone is so fixed, and in the introduction of the ventilating pipes in the stones as herein described.' Now let me implore you, when you look at this patent, not to forget the words, 'as herein described.' For those words 'as herein described' have the effect to a certain extent of incorporating those parts of the patent that are referred to in the claim; those claims would be totally different if it were not for the words 'herein described.' Now we will go back and look at this first claim. 'The first part of my invention consists in introducing air-pipes into the top millstone, so as to more freely ventilate the grinding surfaces when currents of air are forced or exhausted through them. In the top of stone A are placed the air pipes C, C, C, C, which open into the furrows on the face of the stone, and are led away to the eye or back of the stone where the air is introduced" air introduced into the eye. "These pipes I prefer to have of about one inch in diameter, and as many in number as the furrows in the stones so as to give a free ventilation.' Then he mentions other holes and the trumpet-mouthed pipes which are in another specification, and which I will not trouble you with now, and then he says: 'but it will be seen these differ essentially from this part of my invention, and have only been applied to the top stone when running; air has also been exhausted down through the eye of the top stone when running, and between the grinding surfaces. I do not therefore claim the principle except when worked in combination with a fixed upper stone.' This first claim, therefore, is not only from the nature of it, but from the very words of the patent a claim for combination. It is not necessary here that all the parts of it should be new. It is sufficient if it is a new combination. Now I will read it once more and then pass to the next. I must revert to it again when I have very shortly gone through the evidence. 'Firstly, fixing the top stone,' that is one ingredient in the combination, 'and causing currents of air either by exhaustion or pressure to pass between the grinding surfaces,' that is another part of the combination 'when the top stone is so fixed,' that is a careful reference again to the fixing of the top stone, 'and in the introduction of the ventilating pipes in the stones,' then it is ended by the words 'as herein described.' It is in effect causing holes or channels to be made in the top stone called here 'ventilating pipes in the way therein described.

"Now to go very quickly to the second which is the claim to which nineteenths of this evidence relates: 'In exhausting the dusty air when the same has been'—I beg your attention to this—'In exhausting the dusty air when the same has been blown through the grinding surfaces of the millstones from the stone cases or chambers receiving the meal as herein described.' Let me read it once more as shortly as I can. 'In exhausting the dusty air when the same' (that is the same dusty air) 'has been blown through the grinding surfaces of the millstones from the stone cases,' 'as herein described' again. Then we must go back again to the invention to see how much and what it is that he intends to blow away, and what I am about to read to you now is really the very essence of the specification. 'In carrying out the second part of my invention when working millstones with a blast of air, I introduce a pipe to the millstone case from a fan or other exhausting machine, so as to carry off all the warm dusty air blown through between the stones to a chamber as hereafter described, by which the dust in the mill is avoided and the grinding improved.' Observe, it is first of all to carry off 'all the warm dusty air.' If it stopped there it would be all the air. But it does not stop there, 'so as to carry off all the warm dusty air blown through the stones;' that is, all the air that is to be carried away. 'And this part of my invention relates only to sucking away the plenum of dusty air forced through the stones, and not to employing a sufficient exhausting power to induce a current of air between the millstones without a blast, this having before been practised as above-mentioned.'

"Now the claim says: 'exhausting the dusty air from the stone cases, as herein described. 'Herein described' is, take out the air blown in, suck away the plenum, no more. That is the meaning of this claim.

"Now, then, what is the meaning of the word 'plenum.' The word plenum' is certainly embarrassing. I ventured to use the word 'excess,' but a very scientific witness on the part of the defendant, Mr. Bramwell, corrected me, and I think he corrected me simply and naturally so as to make what is said here intelligible. He said, 'I do not like the word 'excess,' I should rather call it fulness.'' The learned counsel whom you have heard, said, I will show you what it means. Suppose there was a cylinder of light porous material filled with air, and it hung down straight; suppose the quantity of that air is increased, then it will bulge out at the sides, and the extent of that bulging would in that case, he said, be the 'plenum;' which seemed to me to be not an inapt illustration, But now here I am relieved from all difficulty, because the three learned judges who have preceded me, have interpreted the word 'plenum,' and I am (whether you are or not, but in point of fact you are as much as me, for you must take the law from me, and I must take it from them) bound by that. They have interpreted this word 'plenum.' No doubt, at first sight, the word 'plenum' might seem to be an unfortunate word, because it naturally carries you back to the word 'vacuum,' and one of you thought scientifically it meant 'plenum' as opposed to 'vacuum.' I do not wonder at any one putting such a construction upon it. But that is not what it means. For your satisfaction I am able to read to you upon this subject the statement of a learned judge, whom I am not flattering when I say there is no judge in Westminster Hall whose *dicta* are entitled to greater consideration, I mean my learned brother, Mr. Justice Willes, when he sat where I now sit trying this cause, and in that he concurs with the judgment of the Master of the Rolls, although I agree the judgment of the Master of the Rolls is not so explicit as it has been reviewed at the bar, but he has been followed by Vice-Chancellor Wood, who does in terms adopt what my brother Willes has said. Now you will have the word 'plenum' therefore defined by the highest authority. My brother Willes says this: 'Now, therefore, the patent is for the application of an exhaust, regulated in such a manner as to carry off, call it the 'plenum,' I should call it the wind produced by the blast coming in; that is, an exhaust regulated according to the force of the blast used to go through the stone.' I do not venture upon any definition myself, but I suppose it is any excess above the natural density of the atmospheric air as charged with stive. There is another observation to be made here upon which something may turn as we go along. There are fierce currents of air driven through the millstones even when there is no super-added blast. I think one witness described as many as 900 cubic feet an hour increased, for I will not say by Mr. Bovill's patent, but in some cases as much increased as 40 per cent.

Mr. Justice Byles: 1260 was the figure my lord.

(*To be continued.*)

ROYAL INSTITUTION OF GREAT BRITAIN.

ON THE TEMPERATURE AND ANIMAL LIFE OF THE DEEP SEA.

By William B. Carpenter, M.D., F.R.S.

The present discourse embodies the most important general results obtained by the exploration of the deep sea in the neighbourhood of the British Isles, carried on during the summer of 1869 in H.M. surveying ship *Porcupine*, with the view of completing and extending the inquiries commenced in the *Lightning* expedition of 1868, of which an account was given by the speaker at the Friday evening meeting of April 9th, 1869.

The expedition of the *Porcupine* was divided into three cruises. The first of these, which was placed under the scientific charge of Mr. J. Gwyn Jeffreys, F.R.S,, accompanied by Mr. William L. Carpenter as chemical assistant, commenced from Galway near the end of May, and concluded at Belfast at the beginning of July. It was directed in the first instance to the south-west, then to the west, and finally to the north-west as far as the Rockall Bank. The greatest depth at which temperature-sounding and and dredging were carried on in this cruise was 1,476 fathoms; and these operations, through the excellent equipment of the *Porcupine* and the skill of her commander, Captain Calver, were so successfully performed, that it was confidently anticipated that still greater depths might be reached with an equally satisfactory result.

The second cruise, which was under the scientific charge of Professor Wyville Thomson, F.R.S., with Mr. Hunter as chemical assistant, was consequently directed to the nearest point at which a depth of 2,500 fathoms was known to exist, viz., the northern extremity of the Bay of Biscay, about 250 miles to the west of Ushant. In this cruise temperature-sounding and dredging were carried down to the extraordinary depth of 2,435 fathoms, or nearly three miles—a depth nearly equal to the height of Mont Blanc, and exceeding by more than 500 fathoms that from which the Atlantic Cable was recovered. This sea-bed, on which the pressure of the superincumbent water is nearly three tons for every square inch, was found to support an abundance of animal life; about 1½ cwt. of Atlantic mud, chiefly consisting of globigerinæ, having been brought up in the dredge, together with various types of higher animals, Echinoderms, Annelids, Crustaceans, and Mollusks; among them a new Crinoid—referable, like the Rhizocrinus, whose discovery by M. Sars, jun., had been the starting-point of the present inquiry—to the Apiocrinite type, which flourished during the Oolitic period.

The third cruise was under the scientific charge of the speaker, with Mr. P. H. Carpenter as chemical assistant; but he had the great advantage of being accompanied by his colleague, Professor Wyville Thomson, who, as in the *Lightning* expedition, took the entire superintendence of the dredging operations. The object of this cruise, which commenced in the middle of August and terminated in the middle of September, was a more thorough exploration of the area between the north of Scotland and the Faroe Islands, which had been found in the *Lightning* expedition to afford results of peculiar interest in regard alike to the inequality of temperature and to the distribution of animal life on the sea-bed, which here ranges between the comparatively shallow depths of from 350 to 650 fathoms—the last-named being the greatest depth to which dredging had been carried in 1868.

The weather during nearly the whole of the *Porcupine* expedition was as favourable to its work, as during the greater part of the *Lightning* expedition it had been unfavourable; and the results obtained not only far exceeded the most sanguine expectations of those who had promoted it, but may be said, without exaggeration, to be such as no previous scientific exploration of so limited an extent and duration is known to have yielded.

The results of the temperature-soundings will be first stated, with their bearing on the doctrines advanced in the former discourse as probable inferences from the observations made during the *Lightning* expedition. These observations indicated that two very different submarine climates exist in the deep channel which lies E.N.E. and W.S.W. between the north of Scotland and the Faroe Banks; a minimum temperature of 32° having been registered in some parts of this channel, whilst in other parts of it, at the like depths, and with the same surface temperature (never varying much from 52°), the minimum temperature registered was never lower than 46°, thus showing a difference of 14°. It could not be positively asserted that these minima are the bottom temperatures of the areas in which they respectively occur; but it was argued that they must almost necessarily be so—first, because it is highly improbable that sea water at 32° should overlie water at any higher temperature, which is specifically lighter than itself, unless the two strata have a motion in opposite directions sufficiently rapid to be recognisable; and second, because the nature of the animal life found on the bottom of the cold area, which consists of quartzose sand, including volcanic particles, exhibited a marked correspondence with its presumed reduction of temperature, whilst the sea bed of the warm area is essentially composed of Globigerina mud, and the animal life which it supports is characteristic of the warmer-temperate seas.

This conclusion, it is obvious, would not be invalidated by any error arising from the effect of pressure on the bulbs of the thermometers; since, although the actual minima might be, as was then surmised, from 2° to 4° below the recorded minima, the difference between temperatures taken at the same or nearly the same depths would remain unaffected.

The existence in the cold area of a minimum temperature of 32°, with a Fauna essentially Boreal, could not, it was argued, be accounted for in any other way than by the supposition of an under-current of Polar water coming down from the North or North-east; whilst, conversely, the existence in the warm area of a minimum temperature of 46°, extending to 500 or 600 fathoms' depth, in the latitude of 60° (being at least 8° above its isotherm), together with the warmer-temperate character of its Fauna, seemed equally indicative of a flow of Equatorial waters from the South or South-west.

It was further urged that if the existence of two such different submarine climates in close proximity can only be accounted for on the hypothesis of an Arctic stream and an Equatorial stream running side by side (the latter also spreading over the former in consequence of its lower specific gravity), these streams are to be regarded (like the Gulf Stream) as particular cases of a great general oceanic circulation, which is continually bringing the water cooled-down in the Polar regions into the deepest parts of the Equatorial ocean-basins, whilst the water heated in the Equatorial regions moves towards the Poles on or near the surface. Such a circulation was long since pointed out to be as much a physical necessity, as that interchange of air between the Equatorial and Polar regions which has so large a share in the production of winds; but whilst physical geographers remained under the dominant idea that the temperature of the deep sea is everywhere 39°, they could not fully recognise its importance.

These doctrines have been fully tested by the very numerous and careful temperature-soundings taken in the 'Porcupine' expedition; and the result has been not merely to confirm them in every particular—so that they may now take rank as established facts,—but also to show that a temperature 2½° below the freezing-point of fresh water may prevail over the sea-bed in a region far removed from the Polar, and that even this extreme reduction is by no means antagonistic to the existence of animal life in great variety and abundance.

All the temperature-soundings of the 'Porcupine' expedition were taken with thermometers protected from the effects of pressure by the enclosure of the bulb of each instrument in an outer bulb, sealed round the neck of the tube; about three-fourths of the intervening space being filled with spirit, but a small vacuity being left, by which any reduction in the capacity of the outer bulb is prevented from communicating pressure to the inner. This plan of construction, which was suggested by Professor W. A. Miller, has been so successfully carried into practice by Mr. Cassella, that thermometers thus protected have been subjected to a pressure of three tons on the square inch, in a testing-machine devised for the purpose, without undergoing more than a very slight elevation, of which a part (at least) is attributable to the heat given out by the compression of the water in which they were immersed; whilst the very best thermometers of the ordinary construction were affected by the same pressure to the extent of 8° or 10°, the elevation in some instruments reaching as much as 50° or 60°. Two of these protected Miller-Casella thermometers were used in each observation; and they always agreed within a fraction of a degree. The same pair was used throughout the expedition; and notwithstanding that they were used for 166 separate observations, in which they travelled up and down nearly 100 miles, they came back in perfectly good order,—a result mainly due to the care with which they were handled by Captain Calver. It may be affirmed with great confidence that the temperatures which they indicated were correct within 1° (Fahr.); an approximation quite near enough for the scientific requirements of the case.

In order to connect the work of the *Porcupine* with that of the *Lightning* expedition, it will be desirable to commence with the third cruise of the former, in which a detailed survey was made of the area traversed in the preceding year by the latter. In this cruise bottom-soundings were taken at thirty-six different stations, at depths varying from 100 to 767 fathoms; of these, seventeen were in the cold area and fourteen in the warm, whilst five exhibited intermediate temperatures, in accordance with their border position between the two. In order to ascertain whether the minimum temperatures thus obtained were really the temperatures of the bottom, serial soundings were taken at three stations, of which one was in the warm area and two in the cold,—the temperature at different depths between the surface and the bottom being ascertained by successive observations, at the same points, at intervals of 50 or 100 fathoms. All these results agreed extremely well with each other; and they closely accorded with the fifteen observations made in the *Lightning* expedition, when the requisite correction for pressure (from 2° to 3°, according to the depth) was applied to the latter.

The following General Summary of these results brings into marked contrast the conditions of the warm and cold areas, which occupy respectively the W.S.W. and E.N.E. portions of the Channel between the north of Scotland and the Faroe Islands, and lie side by side in its midst.

The surface-temperature may be said to be everywhere nearly the same, *viz*,, 52°; the variations above or below this being attributable either to Atmospheric differences (as wind, sunshine, &c.) or to difference of latitude. Alike in the warm and the cold areas there was a fall of from 3° to 4° in the first 50 fathoms, bringing down the temperature at that depth to 48°, A slow descent took place nearly at the same rate in both areas through the next 150 fathoms; the temperature in the warm area at the depth of 200 fathoms being 47°, whilst in the cold it was 45·7°. It is below this depth that the marked difference shows itself. For whilst in the warm area there is a slow and pretty uniform descent in the next 400 fathoms, amounting to less than four degrees in the whole, there is in the cold area a descent of fifteen degrees in the next 100 fathoms, bringing down the temperature at 300 fathoms to 30.8°. Even this is not the lowest; for the serial soundings taken at depths intermediate between 300 and 640 fathoms (the latter being the greatest depth met with in the cold area, midway between the Faroe and the Shetland Islands) showed a further progressive descent; the lowest bottom-temperature met with being 29°·6. Thus, while the temperature of the superficial stratum of the water occupying the cold area clearly indicates its derivation from the same source as the general body of water occupying the warm area, the temperature of the deeper stratum, which may have a thickness of more than two thousand feet, ranges from the freezing-point of fresh water to 2½° below it. Between the two is a stratum of intermixture of about 100 fathoms thickness, which marks the transition between the warm superficial layer and the body of frigid water which occupies the deeper part of the Channel.

The shortest distance within which these two contrasted submarine climates were observed at corresponding depths, was about 20 miles; but a much smaller distance was sufficient to produce it when the depth rapidly changed. Thus near the southern border of the deep channel, at a depth of 190 fathoms, the bottom-temperature was 48°·7; while only six miles off, where the depth had increased to 445 fathoms, the bottom-temperature was 30°·1. In the first case, the bottom evidently lay in the warm superficial stratum; whilst in the second it was overflowed by the deeper frigid stream.

It seems impossible to account for these phenomena on any other hypothesis than that of the direct derivation of the frigid water from the Arctic basin. And this agrees very well with other facts observed in the course of the exploration. Thus:—(1) The rapid descent of temperature marking the "stratum of intermixture" began about 50 fathoms nearer the surface in the most northerly portion of the cold area examined, than it did in the most southerly, as might be expected from the nearer proximity of the cold stream to its source. (2) The sand covering the bottom contains particles of Volcanic minerals, probably brought down from Jan Mayen or Spitzbergen. (3) The Fauna of the cold area has a decidedly Boreal type; many of the animals which abound in it having been hitherto found only on the shores of Greenland, Iceland, or Spitzbergen.

Although the Temperatures obtained in the warm area do not afford the same striking evidence of the derivation of its whole body of water from a Southern source, yet a careful examination of its condition seems fully to justify such an inference. For the water at 400 fathoms in Lat. $59\frac{1}{2}°$ was only 2°4 colder than water at the same depth at the northern border of the Bay of Biscay, in a Latitude more than 10° to the south, where the surface-temperature was 62°·7; and the approximation of the two temperatures is yet nearer at still greater depths, the bottom-temperature at at 767 fathoms at the former station being 41°.4, whilst the temperature at 750 fathoms at the latter point was 42°·5. Now, as it may be certainly affirmed that the lowest temperature observed in the warm area is considerably above the isotherm of its latitude, and that this elevation could not be maintained against the cooling influence of the Arctic stream but for continual supply of heat from a warmer region, the inference seems inevitable that the bulk of the water in the warm area must have come thither from the South-west. The influence of the Gulf Stream proper (meaning by this the body of superheated water which issues through the "Narrows" from the Gulf of Mexico), if it reaches this locality at all—which is very doubtful—could only affect the most superficial stratum; and the same may be said of the surface-drift caused by the prevalence of south-westerly winds, to which some have attributed the phenomena usually accounted for by the extension of the Gulf Stream to these regions. And the presence of the body of water which lies between 100 and 600 fathoms' depth, and the range of whose temperature is from 48° to 42°, can scarcely be accounted for on any other hypothesis than that of a great general movement of Equatorial water towards the Polar area; of which movement the Gulf Stream constitutes a peculiar case modified by local conditions. In like manner, the Arctic Stream which underlies the warm superficial stratum in our cold area, constitutes a peculiar case, modified by the local conditions to be presently explained, of a great general movement of Polar water towards the Equatorial area, which depresses the temperature of the deepest parts of the great Oceanic basins nearly to the freezing-point.

During the first and second cruises of the *Porcupine*, the temperature of the eastern border of the great North Atlantic basin was examined at various depths between from 54 to 2,435 fathoms, and in widely different localities, ranging from Lat. 47° to Lat. 55°. The bottom-temperature was ascertained at thirty stations, and serial soundings were taken at seven stations; making the total number of observations oighty-four. Amongst all these the coincidence of temperatures at corresponding depths is extraordinarily close; the chief differences showing themselves in the temperature of the surface and of the stratum immediately beneath it. A decided super-heating is observable in this superficial stratum, not extending to a depth of much more than 70 or 80 fathoms, and more considerable at the Southern than at the Northern stations. Whether this 'superheating' is entirely duo to the direct influence of solar heat, or depends in any degree on an extension of the Gulf Stream as far as the southern part of the area examined, is a question which can only be resolved by the determination of its relative amount at different seasons. Between 100 and 500 fathoms, the rate of decrement is very slow, averaging only about 3 in the whole, or three-fourths of a degree for every 100 fathoms; and this body of water has a temperature so much above the isotherm of the northern stations at which the observations were made, as decidedly to indicate that it must have found its way thither from a Southern source. Between 500 and 750 fathoms, however, the rato of decrease becomes much more rapid, the reduction being 5°·4, or above 2° per 100 fathoms; while between 750 and 1,000 fathoms it amounts to 3°·1, bringing down the temperature at the latter depth to an average of 38°·6. Beneath this there is still a slow progressive reduction with increase of depth, the temperature falling a little more than 2° between 1,000 and 2,435 fathoms; so that at the last-named depth, tho greatest at which it was ascertained, it was 36°·5.—Thus it is obvious either that the vast body of wator occupying the deeper half of the Atlantic basin has been itself derived from a colder region, or that its temperature has been reduced by the diffusion through it of frigid water from a Polar source. The latter supposition best accords with the gradual depression of temperature exhibited between 500 and 1,000 fathoms, which corresponds with the "stratum of intermixture" of the cold area.

The temperature soundings recently taken by Commander Chimmo, R.N., and Lieutenant Johnson, R.N., at various points of the North Atlantic basin, when the requisite corrections are applied for the influence of pressure on the bulbs of the unprotected thermometers employed by them, give results which are remarkably accordant with our own;* so that it may be stated with confidence that the temperature of the deeper parts of the North American sea-bed is but a very few degrees above the freezing-point.

Now a glance at the North Polar Region, as laid down either on a globe, or any projection of which the Pole is the centre, shows that the Polar basin is so much shut in by the northern shores of the European, Asiatic, and American continents, that its only communication with the North Atlantic basin—besides the circuitous passages leading into Hudson's and Baffin's Bays—is the space which intervenes between the eastern cost of Greenland and the north-western portion of the Scandinavian peninsula. If, therefore, there be any such genoral interchange of Polar and Equatorial water as that for which we have argued, the Arctic current must flow through the deeper portions of this interspace, at the north of which lies Spitzbergen, whilst Iceland and the Faroes lie in the middle of its southerly expanse. Now in the channel which lies between Greenland and Iceland, the depth is such as to give a free passage to such a frigid stream; but between Iceland and the Faroe Islands there is no depth so great as 300 fathoms at any part, except in a narrow channel at the south-east corner of Iceland; so that an effectual barrier is thus interposed to any movement of frigid water at a depth exceeding this. A similar barrier is presented, not merely by the plateau on which the British Islands rest, but also by the bed of the North Sea; the shallowness of which must give to such a movement a not less effectual check than would be afforded by an actual coast-line uniting the Shetland Islands and Norway. Consequently is is obvious that a flow of ice-cold water, at a depth exceeding 300 fathoms from the surface, down the north-eastern portion of this interspace, can only find its way southwards through the deeper portion of the channel between the Faroe and Shetland Islands; which will turn it into a W.SW. direction between the Faroe Islands and the north of Scotland, and finally discharge such part of it as has not been neutralised by the opposing stream coming up from the south-west into the great North Atlantic basin, where it will meet the Icelandic and Greenland currents, and unite with them in diffusing frigid waters through its deeper portion. In thus spreading itself, however, the frigid water will necessarily mingle with the mass of warmer water with which it meets, and will thus have its own temperature raised, whilst lowering the general temperature of that mass; and hence it is that we do not find the temperature of even the greatest depths of the Atlantic basin nearly so low as that of the comparatively shallow channel which feeds it with Arctic water.

It may be questioned, however, whether the whole body of Arctic water that finds its way through the channels just indicated could alone maintain so considerable reduction in the temperature of the enormous mass which lies below 1,000 fathoms in the Atlantic basin; subject as this must be to continual elevation by the surface-action of the sun on its southern portion. And as the few reliable observations on deep-sea temperatures under the equator indicate that even there a temperature not much above 30° prevails, it seems probable that part of tho cooling effect is due to the extension of flow of frigid water from tho Antarctic Pole, even north of the Tropic of Cancer. Of such an extension there is evidence in the Temperature-soundings recently taken in H.M.S. *Hydra* between Aden and Bombay, where the cooling influence could scarcely have been derived from any other source than the Antarctic area.

The unrestricted communication which exists between the Antarctic area and the great Southern Ocean-basins would involve, if the doctrine of a general Oceanic circulation be admitted, a much more considerable interchange of waters between tho Antarctic and equatorial areas, than is possible in the Northern hemisphere. And of such a free interchange there seems adequate evidence; for it is well known to navigators that there is a perceptible "set" of warm surface-water in all the Southern oceans towards the Antarctic Pole; this "set" being so decided in one part of the Southern Indian Ocean, as to be compared by Capt. Maury to the Gulf Stream of the North Atlantic. Conversely, it would appear from the application of the necessary pressure-correction to tho temperatures taken in Sir James Ross's Antarctic expedition, the voyage of the *Venus*, &c., at depths greater than 1,000 fathoms, that the bottom temperature of the deepest parts of the southern oceanic basin really approaches tho freezing point, or is even below it. And if the temperature of the deeper portion of tho North Pacific Ocean should be found to exhibit a depression at all corresponding to that of the North Atlantic, it must bo attributed entirely to tho extension of this Antarctic flow; since the depth of Behring's Strait, as well as its breadth, is so small as to permit no body of arctic water to issue through that channel.

If further observations should substantiate tho general diffusion of a temperature not much above the freezing point over the deepest portions of tho ocean-bed, even in intertropical regions, as a result of a general deep movement of Polar waters towards tho equator, forming the complement of the surface movement of equatorial water towards the poles, It is obvious that such diffusion must exert a very important influence on the distribution of animal life; and, in particular, that we may expect to meet with forms which have hitherto been reputed essentially Arctic, in the deep seas of even the intertropical region, and again in the shallower waters of the Antarctic area. Such, there is strong reason to believe, will prove to be the case. In his recent annual address as President of the Royal Society, Sir Edward Sabine cites observations on this point made by Sir James Ross in his Antarctic expedition, as confirmatory of the view entertained by that distinguished navigator, "that water of similar temperature to that of the Arctic and Antarctic seas exists in the depths of the intermediate ocean, and may have formed a channel for the dissemination of species." The "similar temperature" believed by Sir James Ross to have had this general prevalence, seems to have been 39°; whereas the observations made in the *Porcupine* expedition distinctly prove that a temperature even below 30° may be conveyed by Polar streams far into the temperate zone, and that the general temperature of the deepest part of the North Atlantic sea-bed has more of a Polar character than he supposed.

Again, the deep-sea dredgings of the *Porcupine* expedition have shown that many species of mollusks and crustacea previously supposed to be purely Arctic, range southward in deep water as far as those dredgings extended—namely, to the northern extremity of the Bay of Biscay; and it becomes a question of high interest whether an extension of the same mode of exploration would not bring them up from the abysses of even intertropical seas.

Now, as there must have been deep seas at all geological epochs, and as the physical forces which maintain the oceanic circulation must have been in operation throughout, though modified in their local action by the particular distribution of land and water at each period, it is obvious that the presence of Arctic types of animal life in any marine formation cannot be accepted as furnishing evidence *per se* of the general extension of glacial action into temperate or tropical regions. How far the doctrines now current on this point may need to be modified by the new facts now brought to bear on them, it will be for geologists to determine; the question may be left in their hands with full assurance of a candid reception of the fresh evidence now adduced.

The general results of the dredging operations carried on during the *Porcupine* expedition will now be concisely stated.

In the first place they show conclusively that there is no limit to the depth at which animal life may exist on the ocean-bed; and that the types found at even the greatest depths may be not less elevated in character than those inhabiting shallower waters. It would even be premature yet to affirm that the higher types occur in less abundance and variety than at more moderate depths; for it is by no means impossible that the use of the improved method of collection devised by Capt. Calver, which was employed with extraordinary success in the third cruise, may make as large an addition to our knowledge of the life of the sea-bottom explored by the dredge in the first and second cruises of the *Porcupine* as it has done in the case of the cold area, where it revealed the astonishing richness of the bottom, which the *Lightning* dredgings of the previous year had led us to regard as comparatively barren.

Secondly, they confirm our previous conclusion that temperature exerts a much greater influence than pressure on the distribution of animal life. Not only have we found the same forms presenting themselves through an enormous vertical range—no amount of fluid pressure being incompatible with their existence—but we have also, by a more complete survey of the relations of the warm and cold areas, established the very marked difference between the Faunæ of two contiguous portions of the sea-bed lying at the same depth, which was indicated by the *Lightning* dredgings. It is remarkable, however, that this difference showed itself more in the crustaceans, echinoderms, sponges, and foraminifera, than it did in the mollusca, of which a considerable proportion were common to both areas. The abundance and variety of animal life on a bottom of which the temperature is at least 2° (Fahr.) below the freezing-point of fresh water, is a fact which has all the interest of surprise; and it is scarcely less remarkable that the forms of mollusks, echinoderms, and sponges, which seem to be the characteristic inhabitants of this cold area, should attain a very considerable size. The precise limitation of the globigerina mud and of the vitreous sponges to the warm area, was a very striking manifestation of the influence of temperature, and has very important geological bearings.

Thirdly, they have largely added to the number of cases in which types that had been regarded as characteristic of earlier geological periods, and to have long since become extinct, prove to be still existing in the depths of the ocean; and greatly increase the probability that an extension of the like method of research to more distant localities would produce even more remarkable revelations of this character.

The doctrine propounded by Prof. Wyville Thomson, in the report of the *Lightning* expedition, as to the absolute continuity of the Cretaceous formation with the deposit of Globigerina-mud at present in progress on the North Atlantic sea-bed, has received such striking confirmation from the discovery of the existence of numerous Cretaceous types, not merely in our own explorations, but also in those carried on by the United States Coast Survey in the Gulf of Mexico, that it may be fairly affirmed that the *onus probandi* rests upon those who assert that the formation of true chalk has ever been interrupted since the Cretaceous period. That period is usually considered to have terminated with the elevation of the cretaceous deposits of the European area into dry land. But according to the accepted doctrines of geology, it is highly probable that, coincidently with the elevation of the European area, there was a gradual subsidence of what is now the Atlantic sea-bed; so that the Globigerinæ of the former area, with many accompanying types of animal life, would progressively spread themselves over the latter, as its conditions became favourable to their existence. And there seems no reason why they should not have maintained themselves in its deepest parts, through the comparatively small changes of level which took place in this portion of the earth's crust during the Tertiary epoch.

Fourthly, the *Porcupine* explorations have enormously extended our knowledge of the British Marine Fauna; alike by the discovery of new types, and by the addition of types previously known only as inhabitants of other localities.—The Mollusca alone have as yet been fully examined; and Mr. J. Gwyn Jeffreys, whose authority upon this part of the subject is not second to that of any other Naturalist, reports as follows:—The total number of species of Marine Mollusca enumerated in his recently completed 'British Conchology' (excluding the Nudibranchs) is 451; and to these the *Porcupine* expedition has added no fewer than 117, or more than one-fourth. Of these as many as fifty-six are undescribed, whilst seven were supposed to be extinct as Tertiary Fossils. Sixteen genera, including five which are undescribed, are new to the British seas. "All that I could do," he says, "by continual dredgings in comparatively shallow water during the last sixteen years was to add about eighty species to the number described by Forbes and Hanley. I regard the present (although a large addition) as merely an earnest of future discoveries. In fact the treasury of the deep is inexhaustible." The complete examination of the Crustacea, which are in the hands of the Rev. A. M. Norman, and of the Annelids which have been undertaken by M. Claparède and Dr. Macintosh, will probably yield results scarcely less striking. It is, however, in the Echinoderms and Sponges, which are being examined by Prof. Wyville Thomson; in the Stony Corals, which have been referred to Dr. P. M. Duncan; and in the Foraminifera, which constitute the speaker's own speciality, that the most interesting novelties present themselves.

An enormous addition has been made to the list of British Echinodermata by the discovery in our own seas of a number of species which had been previously known only as Norwegian or Arctic; and these often occurred in extraordinary abundance. One of the most interesting of these was the large and beautiful Feather-star, the Antedon (Comatula) Eschrichtii, hitherto known only as inhabiting the shores of Greenland and Iceland, but now found over all parts of our cold area. On the other hand, the influence of temperature was marked not only by the absence of many of the characteristically Southern types of this group, but by the dwarfing of others to such an extent that the dwarfed specimens might be regarded as specifically distinct, if it were not for their precise conformity in structure to those of the ordinary type. Thus the Solaster papposa was reduced from a diameter of six inches to two, and had never more than ten rays, instead of from twelve to fifteen; and Asterocanthion violaceus and Cribella oculata were reduced in like proportion. But, in addition, several Echinoderms have been obtained which are altogether new to science, most of them of very considerable interest. The discovery, at the depth of 2,435 fathoms, of a living Crinoid of the Apiocrinite type, closely allied to the little Rhizocrinus (the discovery of which by the Norwegian naturalists was the starting-point of our own deep-sea explorations), but generically differing from it, cannot but be accounted a phenomenon of the greatest interest alike to the Zoologist and the Palæontologist. Another remarkable representative of a type supposed to have become extinct, occurred at depths of 440 and 550 fathoms in the warm area; being a large Echinidan of the Diadema kind, the "test" of which is composed of plates separated from one another by membrane, instead of being connected by suture, so as to resemble an armour of flexible chain-mail, instead of the inflexible cuirass with which the ordinary Echinida are invested. This type bears a strong resemblance to the very singular fossil from the White Chalk, described by the late Dr. S. P. Woodward, under the name of Echinothuria floris. Specimens were also obtained, both in the first and third cruises, of a most interesting Clypeastroid, which is closely allied to the Infulaster—specially characteristic of the later Chalk. These constitute only a sample of the interesting novelties belonging to this group, which our explorations brought to light.

Besides further additions to the remarkable group of Vitreous Sponges, which were made in the area over which the Globigerina mud extends, a peculiar and novel form of Sponge was found to be one of the most generally diffused inhabitants of the cold area. This sponge is distinguished by the possession of a firm branching axis, of a pale sea-green colour, rising from a spreading root, and extending itself like a shrub or a large branching Gorgonia. The axis is loaded with Siliceous spicules; and spicules of the same form are contained in the soft flesh which clothes it.

The Foraminifera collected in the *Porcupine* expedition present features of no less interest, though their scale is so much smaller. The enormous mass of Globigerina mud (sometime almost pure, sometimes mixed with sand) that everywhere covers the deep-sea bottom in the region explored, save where its temperature is reduced nearly to the freezing point, may be judged of from the fact that in one instance the dredge brought up half a ton of it from a depth of 767 fathoms. The resemblance of this deposit to chalk is greatly strengthened by the recognition of several characteristically cretaceous types among the Foraminifera scattered through the mass of Globigerinæ of which it is principally composed; as also of the Xanthidia, frequently preserved in flints. Not many absolute novelties presented themselves among the Foraminifera that form true Calcareous shells; the chief point of interest being the occurrence of certain types of high organisation at great depths, and their attainment of a size that is only paralleled in much warmer latitudes, or in the Tertiary or yet older formations. This is especially the case with the Cristellarian group, which has a long geological range; and also with the Milioline, of which specimens of unprecedented size presented themselves. The most interesting novelty was a beautiful Orbitolite, which, when complete, must have had the diameter of a sixpence, but which, from its extreme tenuity, always broke in the process of collection. Of Arenaceous Foraminifera, however, which construct tests by cementing together sand-grains, instead of producing shells, the number of new types is such as seriously to task our power of inventing appropriate generic names. Many of these types have a remarkable resemblance to forms previously known in the chalk, the nature of which had not been recognised. Some of them throw an important light on the structure of two gigantic Arenaceous types from the upper green-sand, recently described by the speaker and Mr. H. B. Brady, an account of which will appear in the forthcoming part of the "Philosophical Transactions;" and there is one which can be certainly identified with a form lately discovered by Mr. H. B. Brady in a clay-bed of the carboniferous limestone.

The question now arises, whether—as there must have been deep seas in all geological periods, and as the changes which modified the climate and depth of the sea bottom were for the most part very gradual—we may not carry back the continuity of the accumulation of Globigerina mud on some part or other of the ocean bed into geological epochs still more remote; and whether it has not had the same large share in the production of the earlier calcareous deposits, that it has undoubtedly had in that of the latter. The Foraminiferal origin of certain beds of the carboniferous limestone, for example, appears to be indicated by the presence of Globigerinæ, long since observed by Professor Phillips in sections of them, as well as by the fact just stated. The sub-crystalline character of these rocks cannot be regarded as in any way antagonistic to such an idea of their origin, since it is perfectly well known that all traces of the organic origin of calcareous rocks may be completely removed by subsequent metamorphism—as in the chalk of the Antrim coast.

What is the source of nutriment for the vast mass of animal life covering the abyssal sea-bed, is a question of the greatest biological interest. That animals have no power of themselves generating the organic compounds which serve as the materials of their bodies—and that the production of these material from the carbonic acid, water, and ammonia of the inorganic world, under the influence of light, is the special attribute of vegetation—is a doctrine so generally accepted, that to call it in question would be esteemed a physiological heresy. There is no difficulty in accounting for the alimentation of the higher animal types, with such an unlimited supply of food as is afforded by the Globigerinæ and the Sponges in the midst of which they live, and on which many of them are known to feed. Given the Protozoa, everything else is explicable. But the question returns—On what do these Protozoa live?

The hypothesis has been advanced that the food of the abyssal Protozoa is derived from Diatoms and other forms of minute plants, which, ordinarily living at or near the surface, may, by subsiding to the depths, carry down to the animals of the sea-bed the supplies they require. Our examination of the surface waters, however, has afforded no evidence of the existence of such Microphytic vegetation in quantity at all sufficient to supply the vast demand; and the most careful search in the Globigerina mud has failed to bring to light more than a very small number of specimens of these siliceous envelopes of Diatoms, which could most assuredly have revealed themselves in abundance, had these Protophytes served as a principal component of the food of the Protozoa that have their dwelling-place on the sea bed. Another hypothesis has been suggested, that these Protozoa, which are so near the border of the vegetable kingdom, may be able, like plants, to generate organic compounds for themselves, manufacturing their own food, so to speak, from inorganic materials. But it is scarcely conceivable that they could do this without the agency of light; and as it is obviously the want of that agency which excludes the possibility of vegetation in the abysses of the ocean, the same deficiency would prevent animals from carrying on the like process.

A possible solution of this difficulty, offered by Professor Wyville Thomson in a lecture delivered last spring, has received so remarkable a confirmation from the researches made in the *Porcupine* expedition, that it may now be put forth with considerable confidence. It is, he remarked, the distinctive character of the Protozoa that "they have no special organs of nutrition, but that they absorb water through the whole surface of their jelly-like bodies. Most of these animals secrete exquisitely-formed skeletons, sometimes of lime, sometimes of silica. There is no doubt that they extract both of these substances from the sea water, although silica often exists there in quantity so small as to elude detection by chemical tests. All sea water contains a certain amount of organic matter in solution. Its sources are obvious. All rivers contain a large quantity; every shore is surrounded by a fringe, which averages about a mile in width, of olive and red seaweeds; in the middle of the Atlantic there is a marine meadow, the Sargasso Sea, extending over 3,000,000 of square miles; the sea is full of animals which are constantly dying and decaying; and the water of the Gulf Stream especially courses round coasts where the supply of organic matter is enormous. It is, therefore, quite intelligible that a world of animals should live in these dark abysses; but it is a necessary condition that they should chiefly belong to a class capable of being supported by absorption through the surface—of matter in solution, developing but little heat, and incurring a very small amount of waste by any manifestation of vital activity. According to this view, it seems highly probable that at all periods of the earth's history some form of the Protozoa—Rhizopods, Sponges, or both—predominated over all other forms of animal life in the depths of the sea; whether spreading, compact, or reef-like, as in the Laurentian and Palæozoic Eozöon, or in the form of myriads of separate organisms, as in the Globigerinæ and Ventriculites of the chalk.

During each cruise of the *Porcupine*, samples of sea water obtained from various depths, as well as from the surface, at stations far removed from land, were submitted to the Permanganate test, after the method of Professor W. A. Miller, with an addition suggested by Dr. Angus Smith for the purpose of distinguishing the organic matter in a state of decomposition from that which is only decomposable, with the result of showing the uniform presence of an appreciable quantity of matter of the latter kind, which, not having passed into a state of decomposition, may be assimilable as food by animals—being, in fact, Protoplasm in a state of extreme dilution. And the careful analyses of larger quantities collected during the third cruise, which been since made by Dr. Frankland, have fully confirmed these results, by demonstrating the highly azotised character of this organic matter, which presents itself in samples of sea water taken up at from 500 to 750 fathom's depth, in such a proportion that its universal diffusion through the oceanic waters may be safely predicated.

Until, therefore, any other more probable hypothesis shall have been proposed, the sustenance of animal life on the ocean bottom at any depth may be fairly accounted for on the supposition of Professor Wyville Thomson, that the Protozoic portion of that Fauna is nourished by absorption from the dilute Protoplasm diffused through the whole mass of oceanic waters, just as it draws from the same mass the mineral ingredients of the skeletons it forms. This diffused Protoplasm, however, must be continually renewed; and the source of that renewal must lie in the surface-life of plants and animals, by which (as pointed out by Professor Wyville Thomson) fresh supplies of organic matter must be continually imparted to the oceanic waters, being carried down, even to their greatest depths, by that liquid diffusion which was so admirably investigated by the late Professor Graham.

Not only, however, has the nutrition of the Abyssal Fauna to be explained—its respiration also has to be accounted for; and on this process also the results of the analyses of the gases of the sea water made during the *Porcupine* expedition throw very important light. Samples were collected not only at the surface, under a great variety of circumstances, but also from great depths; and the gases expelled by boiling were subjected to analysis according to the method of Professor W. A. Miller—the adaptation of his apparatus to the exigencies of shipboard having been successfully accomplished during the first cruise by Mr. W. L. Carpenter. The general average of thirty analyses of surface water gives the following as the percentage proportions:—25·1 oxygen, 54·2 nitrogen, 20·7 carbonic acid. This proportion, however, was subject to great variations, as will be presently shown. As a general rule, the proportion of oxygen was found to diminish, and that of carbonic acid, to increase, with the depth; the results of analyses of intermediate waters giving a percentage of 22·0 oxygen, 52·8 nitrogen, and 26·2 carbonic acid; whilst the results of analyses of bottom waters gave 19·5 oxygen, 52·6 nitrogen, and 27·9 carbonic acid. But bottom water, at a comparatively small depth, often contained as much carbonic acid and as little oxygen as intermediate water at much greater depths; and the proportion of carbonic acid to oxygen in bottom water was found to bear a much closer relation to the abundance of animal life (especially of the more elevated types), as shown by the dredge, than to its depth This was very strikingly shown in an instance in which analyses were made of the gases contained in samples of water collected at every 50 fathoms, from 400 fathoms to the bottom at 862 fathoms, the percentage results being as follows:—

	750 fath.		800 fath.		Bottom, 862 fath.
Oxygen	18·8	...	17·8	...	17·2
Nitrogen............	49·3	...	48·5	...	34·5
Carbonic acid......	31·9	...	33·7	...	48·3

The extraordinarily augmented percentage of carbonic acid in the stratum of water here immediately overlaying the sea-bed was accompanied by a great abundance of animal life. On the other hand, the lowest percentage of carbonic acid found in bottom-water—viz. 7·9—was accompanied by a "very bad haul." In several cases in which the depths were nearly the same, the analyst ventured a prediction as to the abundance, or otherwise, of animal life, from the proportion of carbonic acid in the bottom-water; and his prediction proved in every instance correct.

It would appear, therefore, that the increase in the proportion of carbonic acid, and the diminution in that of the oxygen, in the abyssal waters of the ocean, is due to the respiratory process, which is no less a necessary condition of the existence of animal life on the sea-bed, than is the presence of food-material for its sustenance. And it is further obvious that the continued consumption of oxygen and liberation of carbonic acid would soon render the stratum of water immediately above the bottom completely irrespirable—in the absence of any antagonistic process of vegetation—were it not for the upward diffusion of the carbonic acid through the intermediate waters to the surface, and the downward diffusion of oxygen from the surface to the depths below. A continual interchange will take place at the surface between the gases of the sea-water and those of the atmosphere; and thus the respiration of the abyssal fauna is provided for by a process of diffusion, which may have to operate through three miles or more of intervening water.

The varying proportions of carbonic acid and oxygen in the surface waters are doubtless to be accounted for in part by the differences in the amount and character of the animal life existing beneath; but a comparison of the results of the analyses made during the agitation of the surface by wind, with those made in calm weather, showed so decided a reduction in the proportion of carbonic acid, with an increase in that of oxygen, under the former condition, as almost unequivocally to indicate that superficial disturbance of the sea by atmospheric movement is absolutely necessary for its purification from the noxious effects of animal decomposition. Of this view a most unexpected and remarkable confirmation has been afforded by the following circumstance:—In one of the analyses of surface-water made during the second cruise, the percentage of carbonic acid fell as low as 3·3, while that of oxygen rose as high as 37·1; and in a like analysis made during the third cruise, the percentage of carbonic acid was 5·6, while that of oxygen was 45·3. As the results of every other analysis of surface water were in marked contrast to these, it became a question whether they should not be thrown out as erroneous; until it was recollected that, whilst the samples of surface water had been generally taken up from the bow of the vessel, they had been drawn in these two instances from abaft the paddles, and had thus been subjected to such a violent agitation in contact with the atmosphere, as would pre-eminently favour thorough aëration.

Hence, then, it may be affirmed that every disturbance of the ocean surface by atmospheric movement, from the gentlest ripple to the most tremendous storm wave, contributes, in proportion to its amount, to the maintenance of animal life in its abyssal depths—doing, in fact, for the aëration of the fluids of their inhabitants, just what is done by the heaving and falling of the walls of our own chest for the aëration of the blood which courses through our lungs. A perpetual calm would be as fatal to their continued existence, as the forcible stoppage of all respiratory movement would be to our own. And thus universal stagnation would become universal death.

Thus it has been shown that the bed of the deep sea, even in the immediate neighbourhood of our own shores, is an area of which the conditions have until lately been as completely unknown as those of the ice bound regions of the poles. or of the densest forests, the most arid deserts, the most inaccessible mountain summits, that lie between the tropics; and further, that by the systematic employment of the sounding apparatus, the thermometer. and the dredge, almost as complete a knowledge can be gained of those conditions, as if the explorer could himself visit the abyssal depths he desires to examine. Of the important discoveries in almost every department of science, but more particularly in what Mr. Kingsley has well termed bio-geology, which may be anticipated from the continuation and extension of an inquiry of which the mere commencement has yielded such an abundant harvest, the speaker felt it scarcely possible to form too high an expectation. And, in conclusion, he referred to the systematic and energetic prosecution of deep sea explorations by the United States Coast survey and by the Swedish Government—the results of which prove to be singularly accordant with those now briefly expounded—as showing that other maritime powers are strongly interested in the subject; and expressed the earnest hope that the liberal assistance of H.M. Government, which has already enabled British naturalists to obtain the lead in this inquiry, would be so continued as to enable them to keep it in the future. In particular, he called attention to the suggestion lately thrown out by M. Alex. Agassiz, that an arrangement might be made by our own Admiralty with the naval authorities of the United States; by which a thorough survey, physical and biological, of the North Atlantic should be divided between the two countries; so that British and American explorers, prosecuting in a spirit of generous rivalry labours most important to the science of the future, might meet and shake hands on the mid-ocean.

SOCIETY OF ARTS.

CHANNEL STEAMERS COMMITTEE.

The committee on the models sent in competition for the prizes offered for improved Channel steamers—consisting of Lord Henry G. Lennox, M.P., Chairman of the Council; Rear-Admiral Erasmus Ommanney, C.B.; Capt. Boxer, R.N.; Capt. Tyler; Henry Cole, C.B.; C. W. Merrifield, F.R.S.; E. J. Reed, C.B.; and Seymour Teulon, Vice-Chairman of Council—have presented the following report to the Council:—

"Your Committee, having carefully considered the designs for Channel steamers submitted in competition for the gold and silver medals of the Society, have the honour to report as follows:—

The models received are 17 in number, but your Committee regret to state that three only conform to the conditions laid down by the Council in their public announcement with sufficient closeness to enable your Committee to consider them as entitled to compete.

"After considering all the points in which these three designs differ from the existing vessels, your Committee have come to the conclusion that no one of them presents such features of originality, or such improvements upon the accommodation of the existing vessels, as to justify them in recommending it for either of the medals.

The Council are aware that, in inviting ship designers and others to furnish these models, the draught of water and the tonnage of the vessels were limited to suit the conditions of the present harbours, which preclude the resort to a draught of water much exceeding seven feet, or to a tonnage materially exceeding that of the present vessels. It was unquestionally very desirable, as a first step towards the solution of the great question of Channel traffic, to ascertain whether it was possible to give the public the benefit of greatly improved accommodation subject to these conditions, because the necessity for improvement is very urgent, and this wou'd obviously have been the readiest method of obtaining it.

"The result of the present competition shows that no substantial improvement is to be expected from the voluntary production of designs, even under the stimulus of the offer of the gold medal of the Council, with all the advantages which the award of that medal would, in many cases, bring to the designer.

"It does not necessarily follow that it is impossible to improve the accommodation of the existing boats, and to this point your Committee have given careful consideration. They are of opinion that no such change could be made in the existing boats as would carry with it a large improvement in the accommodation.

"To the adoption of deck houses there are weighty objections, relating chiefly to the navigation of the vessels in stormy weather, and to the entering of the existing harbours under certain circumstances of wind and tide. For these and other reasons your Committee are satisfied that it is not desirable for the Council to take further steps in seeking to effect any substantial improvement in the Channel vessels, while limited to the tonnage and draught of water of the present boats. Minor improvements might be made if the boats were used for passenger traffic only; but your Committee do not understand that it falls within the scope of their duty to offer detailed suggestions of this nature, or to seek to extract them from the various designs which have been submitted, as they take it for granted that the object which the Council has in view is of a much more important character.

"Among the seventeen designs which have been submitted, some exhibit features which would deserve consideration, in determining the best kind of boat to be built for the Channel service, provided the limitations of tonnage and draught of water were removed; but as by the terms of the Council's invitation these designs are excluded from the competition, it was considered undesirable to discuss their details, especially as none of them present any improvement at once so novel and so important as to deserve especial mention in this report.

"The inquiries and investigations which your Committee have made have impressed their minds more strongly than ever with the urgent necessity that exists for some large measure which shall improve the means of communication between this country and the Continent. At present, the forced smallness of the boats, consequent upon the small area and limited depth of water of the harbours and their approaches, results in extreme discomfort to passengers.

"It cannot be for a moment doubted that the engineering skill of England and France is perfectly competent to construct, in a comparatively short time (provided the necessary capital were found) vessels capable of crossing the Channel without the excessive discomfort which is now experienced, and also to construct piers or harbours capable of receiving such vessels under all circumstances of wind and weather, and at all times of tide. In so far as your Committee can ascertain, there is absolutely no practical impediment to these works being undertaken with every prospect of success, provided only the necessary co-operation of the French Government can be obtained."

The Council have adopted the foregoing report, and directed a copy of it to be sent, with the thanks of the Society, to each of the competitors. The Council have also directed copies of the report to be sent to the Emperor of the French and to the French Minister of Agriculture and Commerce, and also to the President of the Board of Trade.

CHANNEL STEAMERS.—Society of Arts Competition, 1869.

No. on Model.	Length on L.W.L.	Extreme Breadth.		Tonnage B. O. M.	Draught of Water.	Height of Saloon Deck above L. W. L.	Deck Area. (Rough).	Area occupied by Passengers.		Free Area.	Provisions for Hatchways, Horses, and Carriages.
		Hull.	Paddles					Saloon.	Open Benches		
	Feet.	Feet.	Feet.	Tons.	Feet.	Feet.	Square Feet.	Square Feet.	Square Feet.	Square Feet.	
1	210	25	45	648	8·7 for. 7·7 aft.	12·5	4,098	3,590	0	508	Small hatchway in saloon deck over engines None shown to hold. Horses and carriages could only be stowed forward.
2	196	24	44	556	7·0	14·5	4,100	2,734	60	1,306	Large hatchway in saloon deck over engines. Companions to forecastle and after cabins. No hatchways to hold shown. Horses and carriages could be stowed right forward and aft.
3	190·5	24	44	540	7·5	13·0	3,895	2,820	0	1,075	No hatchways shown on model, but very complete in drawings. Room for horses and carriages amidships.
4	200	25·5	43	636	7·0	10·5	3,800	1,250	90	2,460	Companions to fore and after cabins, and hatchway to hold. Deck aft free for carriages and horses.
5	227·5	24	42	653	6·0	13·0	4,416	3,104	0	1,342	No hatchways shown. Deck right forward is free for carriages and horses.
6	181	32	52	881	?	?	4,500	2,640	0	1,860	Companions to cabins and hatchways to hold shown. Space for horses and carriages forward between forecastle and bridge.
7	192	32(a)	47	634	9·0	14·0	4,866	1,210	0 (δ)	3,656	Large hatchway over engines, and to fore and after holds. Companions to cabins. Space for horses and carriages in the centre of the vessel throughout its entire length.
8	230	24	41	660	6·5 (γ)	11·0	4,833	3,520	0 (ε)	1,313	Hatchway over engines, and companions to cabins and forecastle, Only space for horses and carriages is right forward.
9	190	28	49	722	8·0	16·0	4,064	2,750	0	1,314	Hatchway over engines, and companions to cabins. Space for carriages and horses forward and aft.
10	201·5	24	40	573	7·0	14·0	4,217	1,480	0	2,737	Companions to cabins. Space for horses and carriages forward and aft.
11	250	27	45	906	6·5	14·0	Saloon deck	extends the	whole length	of vessel.	All necessary hatchways shown.
12	185	25	40	565	8·5 for. 9·5 aft.	11·5	3,619	2,055	0	1,564	Hatchways very complete. Space for horses and carriages forward and aft.
14	200	25	45	615	6·5	12	4,117	2,625	0	1,492	Hatchways over engines and companions to cabins. Space for horses and carriages aft only.
15	202	30(β)	43	881	7·0	11	4,883	2,112	625	2,146	Hatchways to fore hold.

(α). 26ft. for tonnage. (β). Stated to be 24ft. in letter accompanying model. (γ). Stated to be 5·25 in letter accompanying model.
(δ). All seats shown on upper deck are protected. (ε). All seats shown are on the saloon deck.

ON THE INFLUENCE OF THE SUEZ CANAL ON TRADE WITH INDIA.

By Sir Frederick Arrow, Deputy-Master of the Trinity House.

The subject of this evening's discussion is one involving so many novel considerations, and is at the present time so entirely speculative, that there is doubtless a margin for much difference of opinion with regard to it. Many differing views may be and are taken of it, and much sanguine expectation, as well as much reasonable doubt, exists as to the extent of the results which will follow the completion of the Suez Canal. I think, however, that if only on the general grounds of increased communication, it will be conceded that much benefit must accrue to the great Indian possessions of this country, with the welfare of which the question is associated.

It seems to me that the subject may be conveniently viewed under two heads, the one showing how, by means of the canal, India is brought closer to Europe for purposes of commerce, and how new fields of commercial enterprise may be opened up, which hitherto have been inaccessible except at great cost and lengthened periods of transit, economising in the same process that most valuable of all commodities, time; and, under the second head, it may be shown that increased communication and rapidity of transit will make and supply increasing wants, and in so doing develope the resources of India, and distribute them for the benefit of the world at large.

I propose to confine my own remarks to the first of these two branches of the subject, leaving other gentlemen, better qualified than myself, to deal with the second.

It will be necessary, in the first place, to see what distances at the present time have to be traversed between ports of British India and ports of Europe, *viâ* the Cape of Good of Good Hope, and then to compare them with those between the same ports *viâ* the Suez Canal, ascertaining at the same time how, if enhanced freights are required for steamers by the latter route, they will contrast with the loss of time by sailing vessels on the former.

Assuming, then, as a fact that the Suez Canal is so far successful that there are now no obstacles to its being freely traversed by steamships, as ordinarily used for commercial purposes—a fact which, if a matter of doubt at its first opening, is now unquestionable from the use that has already been made of it, and the removal of the only serious difficulties to its navigation—one or two general propositions may be laid down for convenience in argument, and for the purpose of saving further reference, viz.:—That steamers may be considered to average a rate of eight to nine knots per hour, and sailing ships five to six knots per hour, and that uncertainty as to time of delivery can be brought to a certainty by steamers only. In speaking of sailing vessels, I assume that they will practically be the only carriers on the Cape route, and have purposely excluded steamers from consideration as regards that line of traffic, because at the present time it is well known that the expense of the fuel for the long voyage is so great, and the time saved so trifling in comparison, that steamers are not an ordinary means of transit. As science advances in the economising of fuel, there may be an improvement in this direction, but it will require vessels of great power and speed to shorten the mileage now entailed by the prevalent winds within the tropical belt. With these general propositions, and my own experience to guide me, I have drawn out a table which shows, with sufficient accuracy for the present purpose, the comparative mileage transit between port and port actually traversed, and the time occupied in making the passage. They are, taking the Land's End of Cornwall as a common point of departure from England, or ports in Europe north of Brest, as follows:—

Port.	*Via* the Cape.	*Via* the Suez Canal.	Difference.
	Miles.	Miles.	Miles.
Bombay	11,500	6,300	5,200
Kurrachee	11,200	6,100	5,100
Calcutta	13,000	8,000	5,000
Singapore	13,000	8,200	4,800

In point of fact, therefore, to a steamer averaging 8 knots, and to a sailing vessel averaging $5\frac{1}{2}$, which, considering the area they have to traverse at times to make their course and distance good, is the outside that can be allowed to them in the most favourable seasons, the time occupied will be as follows, omitting fractions of days:—

Port.	Steamer in days.	Sailing ship in days	Difference in favour of steamer.
Bombay...............	33 + 3 coaling = 36	87	51
Kurrachee............	32 + 3 „ = 35	85	50
Calcutta	42 + 5 „ = 47	99	52
Singapore	43 + 5 „ = 48	51	51

Having thus disposed of the question of mileage and time, it remains to seen whether these advantages compensate for the increased cost of navigating a steamer. This is not very easy to arrive at, for there are at present so many varieties of engines and such differences in the cost of the motive power, the principal element, that any sort of average would be fallacious. I propose, however, instead to take as an example a class of vessel now being built, combining carrying capacity and economy of fuel and wages, which will, I think, be a type for this trade, and to compare it with an average sailing vessel of the class mostly used in the trade, founded upon the experience of actual voyages made, the two vessels being of about equal carrying capacity, say about 1,200 tons burthen each. I find that, as regards times of transit of the latter, they nearly coincide with the calculations I have above made, but independently of them. The steamship will carry, in addition to her stores and coal for 28 days, 900 tons of goods; the sailing vessel, 1,200 tons.

The portage bills for both vessels are nearly the same; the canal rate on the steamer is about 6s. per ton on 900 tons of freight—say, £270. The cost of coal may be averaged at 35s. at all ports, and the amount consumed on a passage to Calcutta would be a little over 400 tons. Taking, therefore, as an example the voyage in which the sailing vessel would do best, viz., from Calcutta to London, the following would be an approximation to the result:—The steamer would do the distance in 47 days, her expenses being—coal, £700; wages, £300; canal dues, 270; total, £1,270; and she would deliver 900 tons of goods, say at £3, £2,700; leaving net earnings, £1,430. The sailing ship would deliver 1,200 tons in 99 days, the wages, steam hire, &c., would come to at least £700, and crediting her with the same rate of freight, would net £2,900, or as near as possible double that of the steamer, and occupying more than double the time. As the steamer, therefore, will make two voyages to the sailing ship's one, it seems to me the case is made out that the canal can compete successfully with the Cape route. I have not attempted to go into minute calculations as to insurance, repairs to vessels, original cost, &c., but I think I have gone far enough to prove that steam can compete, *viâ* the canal, with sailing vessels by the Cape. I have purposely put the case favourably to the latter. I have taken the freight at equal rates. I have not touched on a round voyage, when not only would the outward freights be more against the sailing ships, and the cost of coal more in favour of the steamers, but the loss of time would be still greater, and I have taken the port of Calcutta as furthest to the eastward, and therefore more favourable to the sailing vessel. On the west side of India, the results would be proportionately more in favour of the steamer, as I have stated in a little pamphlet, lately published, a copy of which I had the honour to send to this Society.

Assuming it as proved that the Suez Canal can compete with the Cape route, let us see what further advantages it presents. I think we may say it will probably open a considerable trade between India and Italy, the Morea, Islands of the Grecian Archipelago, and the countries bordering the Mediterranean, including Spain, whose industry, although still undeveloped, is represented by many cotton and other factories at Barcelona and elsewhere on its Mediterranean shore. It will probably create a direct trade between the coasts of the Black Sea and India, by placing the latter in direct communication with Russia and her teeming population. By the Cape route all these places are excluded from direct communication, except perhaps those immediately contiguous to the Straits of Gibraltar, and we may consider Marseilles as the point at which supply comes no longer from the westward.

On a previous occasion, a remark was made that there was not much credit due in making this canal. It was said that it was simply supplying a want for which the time had come. It struck me then that no greater compliment could be paid to the eminent man by whose perseverance and energy the undertaking has been carried out, and I accept it as conveying what, in my opinion, is the highest praise that can be bestowed on it. I believe it is a real want, and that its supply is another link in the chain which binds mankind together, and in which each successive link of discovery of nature or science is forged with stronger power. It is within my memory, as of many here, when the first steamboats were put on the waters, when the iron horse first traversed the rail: and we have all seen how the necessities of those great advances in communication required still further development. Thought was required to travel faster than locomotion by the very advantages the latter gave, and then came that wonderful discovery of the electric telegraph, now being carried to such perfection that, ere another two years have passed away, we may feel the furthest ends of the world to be as practically familiar to us as are now Paris or Vienna; but this again creates fresh wants, requires greater rapidity, regularity, &c., and in obedience to this law, the Suez Canal has been formed.

I will not pursue the theme—it is as diversified as it seems to be endless; but I claim for the Suez Canal and the enterprise of its great and large-minded author a fair and full recognition. At the present moment its influence is being felt in a decrease of the cost of fuel east of the Isthmus, which certainly will have great effect on the cost of carriage, and therefore in the cost of laying down produce and goods. The existence of this route, it appears to me, will stimulate production not only in India but in the various countries which it brings into the family of commercial relations, and seems to me the natural channel for the produce of India. If so, it must increase that produce, and must benefit India itself. England wants cotton, so do other countries—a want likely to increase—and at the moment that a network of railways has connected the great port of Western India with the cotton districts, comes into being that channel which will most quickly and cheaply take the staple to the place where it is needed. From the north-west by the Indus and the railway system of the Punjaub, another great feeder to it opens, while the rail from Madras to Baypore on the west coast gives a speedier and cheaper transit from the east coast of India, *via* the Canal, than by the Cape. These are considerations, however, which come more under the second head of this subject, and I do not propose to enlarge upon them, as they will be, I am sure, done justice to by those better able to handle them than myself.

ROYAL GEOGRAPHICAL SOCIETY.

At the usual meeting of this Society on the 14th ult., the President, Sir Roderick Murchison, read an official letter he had that day received from Lord Clarendon, stating that a severe outbreak of cholera had occurred in East Africa, at Zanzibar, and the neighbouring mainland, which it was feared would delay the progress of Dr. Livingstone, inasmuch as the native carriers who were taking supplies to him had been attacked by the epidemic. Sir Roderick stated that there was little probability of the disease reaching the remote interior district, where Livingstone remained waiting for the Zanzibar caravan. The paper of the evening was "On Morrell's Antarctic Voyage, and on the advantages of Steam Navigation in future Antarctic Explorations," by Capt. R. V. Hamilton, R.N. According to the author a remarkable narrative of a voyage in high southern latitudes by Benjamin Morrell, in a sealing schooner, published at New York in 1831, had been hitherto overlooked by all concerned in Antarctic exploration. Even Morrell's celebrated countryman, Commodore Wilkes, seems not to have been aware of this publication, which appeared before he sailed on his voyage of discovery. Captain Hamilton had laid down Morrell's route on a South Polar chart, and found that it intersected several times the land said afterwards to have been discovered by Wilkes. The portion of the Antarctic Ocean navigated was between 66deg. and 70 deg. 14min. S. latitude and between 105deg. E. longitude and the meridian of Greenwich. South of 64deg. he found less ice, and in 69deg. 11min. S. there was no field ice visible. Captain Hamilton concluded that the Antarctic lands seen by Wilkes and others were mostly islands, and that one or other of them would offer a suitable site for the observation of the approaching transit of Venus. The employment of steam vessels, he contended, would add very greatly to the safety of the expedition as well as the facility of reaching the high southern latitudes. The great barrier of ice surrounding the South Polar lands he believed was not glacier ice, but an enormous floe. In the discussion which followed Commander J. E. Davis (of Sir James Ross's expedition) dissected many of Morrell's statements about well-known places in high southern latitudes, and showed that they were almost all pure fiction; he considered his work to be, therefore, of no authority, and denied that it had been overlooked. It had been examined by chartographers and writers, and set aside as unreliable. Mr. Enderby expressed similar opinions, from personal knowledge of Morrell; and Mr. F. Galton also exposed Morrell's inaccuracy with regard to the interior of south-west Africa. Captain Sherard Osborn differed in opinion from Captain Hamilton regarding the formation of the Antarctic ice barrier, and believed it to be the seaward edge of an enormous continental glacier. Admiral Ommanney also took part in the discussion. The following new members were elected:—Charles Ashton, William J. Anderson, Louis Alford, Charles Fairbridge, Charles W. Gray, Edward Gellatly, J. G. Gibson, T. D. Mackay, Rev. W. R. Tilson Marsh, M.A., M. le Chevalier de Overbeck, Robert T. Pigott, Albert Walker, Thomas Watson, and Peter T. Wills.

MANCHESTER STEAM USERS' ASSOCIATION.

THE EXPLOSION OF KITCHEN AND CIRCULATING BOILERS.

At the last meeting of the Executive Committee of this Association held on Tuesday, the 22nd of February, at the offices 41, Corporation-street, Manchester; Thomas Schofield, Esq., Cornbrook, taking the chair in the absence of the President, Sir W. Fairbairn, C.E., F.R.S., &c., Mr. L. E. Fletcher, Chief Engineer, briefly referred to the number of fatal household boiler explosions that have recently occurred. This meeting had been specially convened for the purpose of considering the annual report to be laid before the body of subscribers at the approaching general meetings, but, owing to the number of lives which had been lost by the explosion of these household boilers during the recent frost, it was thought important to circulate at once some suggestions with regard to the cause of these disasters, with the hope of preventing their recurrence should the frost return. Under these circumstances the subject was only briefly touched on, the Chief Engineer hoping to treat it more fully, with the aid of illustrations, in his next ordinary Monthly Report.

The cause of kitchen or bath boiler explosions is very much misunderstood, and thence the constant recurrence of these disasters. They are wrongly ascribed to the introduction of a few drops of cold water into a red hot boiler. They are attributed to the thaw, whereas they are the result of the pipes being sealed by the frost. That the sudden introduction of cold water into a red hot boiler will not cause an instantaneous generation of pressure sufficient to produce an explosion, was shown by repeated experiments, fully described in the Chief Engineer's Report for January, 1867.

The boilers that explode on the occurrence of frost are on the circulating principle. They are connected by two pipes to an overhead cistern, the result of which is that on the application of a fire to the boiler, as soon as the water becomes heated it rises through one of these connecting pipes, while the cold water, by its gravity, descends in the other, so that a constant circulation is kept up as long as the fire remains in action, the boiler and pipes are full, the passages open, and there is any water left in the overhead cistern. As long as these pipes are open they form a natural safety-valve, and afford a pressure due to the height of the column of water, and no more; but as soon as the frost seals them up the pressure accumulates as long as the fire burns, when explosion becomes merely a question of time. This is the simple cause of these disastrous explosions, and that being so, it is clear that all that is needed to prevent them is to adopt the very simple precaution of fixing to every circulating boiler a reliable safety-valve, that will not be affected by the frost. A drawing of a safety-valve, recommended for this purpose, was given in one of the Association's printed monthly reports three years since, when attention was called to the subject, in consequence of a number of fatal explosions that occurred during a frost at that time. The valve recommended was of the external pendulous dead weight construction, and, having no lever, hinged joint, wings, or spindle, was not at all liable to derangement, while hundreds of similar valves of larger size, on steam boilers, have worked satisfactorily under the inspection of this Association for years. These valves should be fixed in the front of the range, being brought out, if necessary, by means of a connecting pipe, so as to be always in sight and accessible. They should be kept clean and bright—treated as an ornament, and then they can be depended on; but safety-valves, if stowed away in a dark corner, and left out of sight for years, prove in nine cases out of ten, especially when of the ordinary lever, hinged joint construction, to be stuck fast and useless just when they are wanted. These safety-valves are very inexpensive; any brass founder should be able to turn them out, and every householder should have one applied, or some other simple contrivance for preventing the accumulation of pressure during all states of weather. It is possible that there may be other contrivances more convenient than the safety-valve, and it is proposed to return to this subject on a future occasion, but from the number of fatal explosions which have recently occurred it is important to call public attention to this subject immediately, and if it is once fairly recognised that the cause of these explosions is a gradual accumulation of pressure, it will not be long before some suitable measures are contrived to meet it. To set a boiler in a kitchen alongside of a brisk fire without a safety-valve, or something equivalent thereto, is very much like putting a cask of gunpowder into the oven to bake.

UNITED SERVICE INSTITUTION.

IRONCLADS, PRESENT AND FUTURE.

By MR. C. F. HENWOOD.

The following is an abstract of the paper on this subject read in the lecture theatre on the 7th ult., by the author:—

The author stated that the country possessed in all but 47 ironclads, which had been divided by the Admiralty into no less than 13 different classes. Such a classification simply exhibited what a medley collection we possess. It had been stated by Sir William Fairbairn that "it is essential that the steam navy of this country should be able to manœuvre at sea with the precision of a squadron on parade." Our present ironclads were incapable of performing such evolutions, for their maximum speeds were too various, some 11 knots and others 14 knots at sea; they also varied considerably in handiness—the long ships having small rudders, while the short ships have large rudders. In respect therefore of squadron evolutions our present ironclad navy was not in a satisfactory condition. The reader pointed out defects of the six vessels of the *Audacious* class, especially noting the fact that their maindecks, which are only 4ft. above the water, are protected simply by steel plating 5-16ths of an inch thick covered with a wooden deck 3½in. thick. The author further argued that the *Captain* was, on the whole, superior to either the *Hercules* or the *Monarch*, for although the *Hercules* was more strongly armour-plated at the waterline, her battery and other portions were inferior to the defensive powers of the *Captain*. The *Captain* and the *Monarch* are armed with four 600-pounders, and two 114-pounders, throwing a broadside of 2,515lb., while the *Hercules* can throw but 2,080lb. The *Captain* is 1,000 tons smaller than the *Hercules* and 390-horse power less, and taking the same rate per ton and horse-power for each, the *Captain* would cost £62,800 less than the *Monarch*, and £77,220 less than the *Hercules*. The *Captain*, therefore, Mr. Henwood considers, takes her place at the head of all our sea-going ironclads, as the most powerful, and at the same time the most economical. The *Devastation* and *Thunderer* are turret vessels without masts or sails; they are to carry four 600-pounders in two turrets, which are surrounded by a breastwork invented by Captain Coles in 1865. The hull, breastwork, and turrets will be plated with 12 inches of solid iron; but these powerful and costly vessels will not be fast. Their estimated speed is but 12½ knots. The speed of our earliest ironclads is 14 knots, which speed is now maintained by most of our Transatlantic steamers. The latest ironclad ordered, an improved *Devastation*, named the *Fury*, is estimated to have 13½ knots, but as the *Thunderer*, to be built at Chatham, is not yet laid down, it would be wise to reconstruct her and increase her speed from 12½ knots to at least 13½, the same as the *Fury*. The author further stated that it is more than probable than within the next two or three years we shall possess 1,000-pounder guns, for the Russian Government do already possess such a gun, weighing 50 tons, throwing projectiles of 1,000lb. weight, with a charge of 130lb. of powder. Again, it is possible that the hydraulic propeller may prove more suitable for ships of war than the screw, that liquid fuel may supersede coal for generating steam, and that an efficient plan for sheathing the bottoms of our iron ships with zinc may be discovered. Considering that these at present unsolved problems may, and undoubtedly will, cause another reconstruction or our navy, involving an expenditure of £12,000,000 or more, the author believes it most unwise to lay down at the present time new ironclads which will take two or three years to complete, at a cost of £300,000 apiece. But, having regard to the national necessity for increasing the number of our present ironclads—a necessity admitted by the Admiralty—we might convert the best of our screw line-of-battle ships into practically as good ironclad turret vessels as the *Devastation*, which would involve but one-third the outlay in time and money. At the same time a portion of the money thus saved might, with advantage to the country, be expended in making judicious and exhaustive experiments for solving the above questions. Thus should we secure real economy with efficiency.

INSTITUTION OF NAVAL ARCHITECTS.

ANNUAL GENERAL MEETING.

This institution will open its annual general meeting on Wednesday, the 6th April, in the Lecture Theatre of the South Kensington Museum, which has been placed at the disposal of the members by the courtesy of the Committee of Council on Education. The remaining three days of the week the Institution will meet as usual, through the permission of the Society of Arts, in their Great Hall, in John-street, Adelphi. The meeting at South Kensington has been arranged with the view both of obtaining a little extra time for the discussions upon the papers read, and in order to enable the members and associates and their visitors to inspect the premises of the Royal School of Naval Architecture, and the valuable collection of Models of Ships and Marine Engines in the Naval Gallery at South Kensington. The programme of papers to be read has not yet been completely settled, but some interesting contributions to the theory and practice both of Naval Architecture and Marine Engineering have already been promised.

THE INSTITUTION OF CIVIL ENGINEERS.

ON THE NEW MHOW-KE-MULLEE VIADUCT, GREAT INDIAN PENINSULA RAILWAY,

By Mr. A. R. Terry, Assoc. Inst. C.E.

The work described in this communication was to replace a structure of masonry, which failed on the 19th of July, 1867, after having been completed and in use for about four years. To carry on the traffic, which amounted to eighteen trains per day, during the reconstruction of the viaduct, a line of rails was laid on the surface of the Mhow-ke-Mullee ravine, in such a manner that the trucks, descending freely on one side, could work up the greater part of the other side by the momentum acquired, when they were drawn up to the top by engine power. This temporary line descended to the centre of the ravine by gradients of 1 in 20 and of 1 in 7½. The length from the starting point to the bottom was 1,000ft., and the depth descended 56ft. There were similar gradients on the other side, with curves of 20 chains and of 10 chains radii, until, at 1,400ft. from the commencement of the incline, a crossing was introduced, the gradients adopted being 1 in 37 and 1 in 5⅝ for a distance of 360ft. beyond the points. From the crossing a line was constructed in the opposite direction, with a curve of 5¼ chains radius, and a gradient of 1 in 8¾, for a length of 400ft., and then straight and level for a distance of 210ft., to turntables at the end of the main line. For eight months, the traffic was successfully carried by this temporary line, at the average daily rate of two hundred and fifty wagons. The trains which ascended the Ghauts were divided into lots of two wagons each, and were pushed over in pairs from the main line on to the tramway by a locomotive. In descending they acquired sufficient velocity to ascend the other side of the gap to within 150 yards of the main line, and for that distance they were drawn by means of a rope attached to a powerful engine.

The new structure consisted of masonry abutments, 26ft. in advance of the old abutments, and of one solid ashlar pier, the two openings being crossed by iron girders, four to each span, of the triangular kind known as the Warren truss, which were originally intended for another viaduct on an unopened portion of the line. These girders were each 206ft. in length, (the distance between the end pins being 202ft.,) and 22ft. 6in. in depth, and they were placed directly under each line of rails. Their total weight was 812 tons, or rather more than 100 tons each.

A staging was carried across the ravine, at a height of about 63ft. above the *debris* of the old work, on which the girders were erected. There were two platforms, the one 18ft. below the other, both 36ft. wide, and both supported by heavy timbers, resting on cast iron columns. In putting the girders together, the parts of the boom were laid in a straight line, and to a camber of 3in. in excess of the ultimate camber of 5in. The sides of the triangles were then slipped in from underneath, and fixed to each part, and were further joined at the ends by steel pins. The links of the bottom chain were afterwards put on these, and connected at the intermediate joint. Then the parts of the boom were let down, till they joined closely together, and were riveted up. The connecting pins were driven by wooden rams generally in less than three hours. Screw presses, specially designed for this work, failed entirely; as it was found absolutely necessary to give a blow of some kind.

In order to raise the girders from the platforms on which they were built, a height of 63ft., and to lower them on their bearings, machinery of the following description was employed: the machinery consisted of a wrought-iron frame on wheels, to which was fixed a cast-iron press cylinder, fitted with a plunger 6in. in diameter, capable of moving through a length of 2ft., the load being suspended by a cross-head and two linked chains. There were two force pumps, one on each side of the lifting plunger, worked by fifteen men at each end of a rocking lever in the usual way. The two chains were each of two bars, in lengths of 12ft., and pierced at every 2ft., with holes for stopper pins. On each side of the hydraulic ram, they passed through a hollow cast-iron standard, with slots in the sides, fitted to receive the stopper pins; so that the load could be transferred from the press plunger to these standards at the end of each 2ft. stroke. The men worked at the rate of twenty-five strokes per minute, and the speed of lift was 12ft. per hour. The four girders of one span were lifted and bedded in seven days; the hoisting machinery was then transferred to the second span, which occupied four days; and the four girders of that span were raised and placed in four days—or altogether fifteen days after the act of hoisting had been commenced.

The girders were tested by a train composed of seven engines, each weighing 55 tons, the absolute load bearing on each span being 357 tons, or 1½ ton per lineal foot of single line, when the greatest deflection produced was 1⅝in. and the permanent set was less than $\frac{1}{16}$ of an inch. The train was then run over at a speed of from 10 miles to 12 miles an hour, when very little motion was observed. On the 1st of July, 1868, or nineteen days within twelve months after the first viaduct fell, the trains resumed their old route across the Ghauts.

The expenditure for labour alone at the site of the works amounted to nearly £8,000, or £10 per ton of bridge work erected, including a sum of 65s. per ton, paid subsequently to the opening of the viaduct, for the removal of the building stages. The cost of the solid ashlar pier and of the new masonry in the abutments was £36,100.

ON THE PENNAIR BRIDGE, MADRAS RAILWAY.

By Mr. E. W. Stoney.

This bridge was 1,674ft. in length between the abutments, divided into twenty-four openings of 64ft. each, by masonry piers 6ft. thick, twelve (six at east end nearest the abutments) being founded on solid masonry, and the remaining eleven in the centre on brick wells. Details were given of the mode of putting in the foundations and of the fair work of the abutments and of the piers. The average height of the piers, from the bed of the river to the underside of the girders, was 20ft.; while they measured 29ft. in length, being built for the reception of a second set of girders, should it hereafter become necessary to double the line.

The superstructure consisted of wrought-iron plate girders arranged in pairs, 8ft. apart from centre to centre, each pair being 139ft. 10in. long, and continuous over two openings, connected transversely by means of seven plates and twelve crossbracing frames. The girders were of the double T section, 4ft. deep, and consisted of similar top and bottom flanges. Each girder, as sent from England, arrived where it was to be erected in five sections, of the following lengths, viz: two abutment pieces of 21ft. 4in., two intermediate pieces of 30ft., and one centre piece of 37ft. 2in. The weight of each set of girders complete was 37 tons 3 cwt., and of the sleepers and permanent way for each length of 140ft. 11 tons 17 cwt., so that the total dead load was 49 tons, or 7 cwt. per lineal foot of roadway, equivalent to 3½ cwt. per lineal foot on each girder of the pair forming one set. The greatest running load did not exceed 10 cwt. per lineal foot on each girder, so that the maximum load to be sustained was about 13½ cwt.

In order to build the girders, a length of about 300ft. of embankment behind each abutment was levelled to a height of 1ft. above the girder stones, this area allowing four sets, two abreast, to be set up at one time. The first pieces of girder arrived from Madras by railway on the 21st of October, 1868. Setting was begun on the 24th of the same month, and by the 24th of December all the riveting was completed, as well as eight sets rolled; and the whole would have been rolled and in place by the end of that month, if the masonry of all the piers had been ready for their reception. In these two months there were only fifty-five working days, during which time twelve sets of girders were unloaded, set up, and joined together by thirty-four thousand rivets; the whole comprising one hundred and twenty pieces of girder, two hundred and twenty-eight bracing frames, as well as all cover plates and other fittings, together weighing upwards of 370 tons. Four sets of girders were constantly worked at by four sets of men—one set of men being employed in unloading and setting up, another in fitting and screwing them up ready for the riveters, a third in riveting, and the fourth in rolling the girders across opening after opening, until they reached their destination. On the completion of the riveting, each set of girders was lifted with screw jacks about 18in., and double-headed rails, laid flat, were affixed to the lower flange. The end rails were allowed to project 12ft., so as to relieve the girders from the overhanging strain as early as possible. Three platforms of sleepers were now made, and on these, directly under the rolling rail, twelve cast-iron rollers arranged in groups of four were placed. Upon these the girders were lowered. Four similar rollers, secured to sleepers, having been placed on the girder stones of the abutment and the piers to be passed over, it only remained to fix the hauling tackle, which consisted of double purchase crab winches, secured to sleepers resting on the top flanges over the centre of the girder. A large double block was then attached to a bracing frame in front of the girder, and another similar block rested on the top of the second pier forward, and there was passed through these blocks a 6in. Manilla rope, one end being secured round the second sheave of the first block, while the other end, after taking a couple of turns round the crab barrel, was passed back to two men, who coiled it as fast as it was wound in on the sleeper platform behind the crab. The rate of rolling was about 1ft. per minute, provided no delays occurred; but owing to the time taking up in shifting tackle, and other occasional hindrances, the average rate of progress did not exceed four or six openings a day, or a distance of 420ft., in nine working hours. It was stated that the rolling system had been in use on the Madras Railway for some years, and that it had been found to be cheaper, safer, and more expeditious than the ordinary way of riveting on staging. The system had been applied with advantage to the placing in position of girders of much larger span than those described, by the introduction of a simple temporary trussing to support the overhanging portion in rolling. The lattice girders of a viaduct on the Paris and Orleans Railway spanning openings of 164ft. were so rolled, as were also the plate-girders of the Grand River Bridge, Mauritius Railways.

The cost per set for erecting and fixing the girders in place, exclusive of the value of large tools, was £81, or £40 10s. per opening. The cost of fixing rails, rolling and lowering was about 34s. per opening. The value of materials used and depreciation of plant did not exceed £15 per set.

The Pennair Bridge was opened for public traffic on the 1st of August, 1869. The maximum deflection of the girders at the centre, with two engines coupled standing over and just covering one opening, was ½ an inch; this deflection was increased $\frac{1}{32}$ or $\frac{1}{16}$, or say a total of $\frac{9}{16}$ an inch, when the same engines were run at a speed of 40 miles an hour over the bridge. With both spans uniformly loaded, the points of contrary flexure were each 48ft. from the abutment piers, and the points of maximum deflection 24ft. from the same. When, however, one span only was loaded (say with engines) the point of flexure in the loaded span was about 54ft. from the abutment, and the point of maximum deflection was situated at about 27ft. from the face of the same abutment. The calculations from which these results were derived were given in an appendix.

THE WOLF ROCK LIGHTHOUSE.

By Mr. Jas. N. Douglass, M. Inst. C.E.

Before entering upon the immediate subject of the paper, the author noticed briefly some other works which had been executed from time to time in the same neighbourhood, and with which it was intimately connected. These included a lighthouse on the Longships Rock, built of granite in 1795, and from which a catoptric fixed light was exhibited. Owing to the terrific seas to which it was exposed, the lantern, with its centre at an elevation of 79 feet above high water of spring tides, was so much under water during stormy weather, that the character of the light could not be determined with accuracy. In its stead a granite column 110 feet was now being erected, to be surmounted by a first order dioptric light. In the same year, 1795, beacons were erected on the Wolf and the Rundlestone Rocks. These works were described, as well as a second beacon erected on the Rundlestone during the years 1841-3, the mast of which was on several occasions carried away and had to be reinstated. The dangers of the Rundlestone had since been marked by a bell buoy. An iron beacon was also erected on the Wolf Rock during the years 1836-40, and during these five years it was only possible to work on the rock for thirty and a quarter days of ten hours each. The mast of this had likewise to be renewed several times. The ironwork of this beacon, after an exposure of thirty years to the corrosive action of sea water, was in a good state of preservation, having been protected by a coat of good red lead paint, renewed annually,

The Wolf Rock was stated to be composed of hard, dark, felspathic porphyry. Its highest part was 17 feet above high water of spring tides, which had a rise of 19 feet. The surface was rugged, rendering a landing upon it difficult. The depth of the water close to the rock was 20 fathoms, excepting on the south-east side, where a shoal extended for a considerable distance. The success which had attended the efforts of the Trinity House in the erection of lighthouses on the Bishop Rock, Scilly, on the Smalls Rocks, at the entrance of the British Channel, and on the Hanois Rock, at the west end of Guernsey, induced the corporation to undertake the erection of a lighthouse upon the Wolf Rock. In the year 1860 the late Mr. Walker (Past President Inst. C E.), was instrusted to furnish a design for, and an approximate estimato of, the work. These having been approved, the author, who was then completing the Smalls Lighthouse, was appointed to carry out the work as resident engineer. The form and dimensions of the tower differed but little from those on the Bishop, the Smalls, and the Hanois. Its exact height was 116 feet 4¾ inches, its diameter at the base 41 feet 8 inches, and near the top at the springing of the curve of the cavetto under the lantern galley, the diameter was 17 feet. For a height of 39 feet 4½ inches from the base the work was solid, with the exception of a space forming a tank for fresh water. At the level of the entrance door the walls were 7 feet 9½ inches thick, whence they gradually decreased throughout the whole height of the shaft to 2 feet 3 inches at the thinnest part near the top. The shaft of the tower was a concave elliptic frustrum, the generating curve of which had a major axis of 236 feet, and a minor axis of 40 feet. It contained 44,506 cubic feet of granite, weighing about 3,296¾ tons; and its centre of gravity was 36 feet 2¼ inches above the base. In consideration of the exposed position of the work, it was determined to dovetail each face stone vertically and horizontally, in accordance with the system suggested by the author's father, and first adopted at the Hanois Lighthouse. This method consisted in having a raised dovetailed band, 3 inches in height, on the top bed and one end joint of each stone. A corresponding dovetailed recess was cut in the bottom bed and end joint of the adjoining stones, with just sufficient clearance for the raised band to enter it freely in setting. From experiments made upon blocks of granite put together in this manner with Portland cement, it was found that the work was so homogeneous as to be nearly as possible equal in strength to solid granite. In addition to increased strength, this system of dovetailing afforded great protection to both the horizontal and the vertical joints, against the wash of the sea when the work was first set. As an additional precaution, each stone of the first twenty courses was also secured by two bolts to the course below. The masonry, to the level of high water spring tides, was set in fresh Medina Roman cement, part of which was supplied from the Government Stores at Chatham, and part was manufactured by Messrs. Francis and Co., from whom the Portland cement was obtained for setting the work above high water. All the cement used in the work was mixed with an equal portion of clean, sharp, granitic sand, obtained from the stamps refuse of the Balleswidden Tin Mine, near Penzance. This sand was of excellent quality for such work, every grain in it being hard, angular, and rough. Salt water was used for mixing all the cement required for the landing platform and for the solid portion of the tower; above this fresh water was used. The step ladders for ascending from floor to floor, and the partitions between the rooms and staircase, were of cast iron, and precautions had been taken to limit the use of wood for the fittings as much as possible, in case of fire. The doors, windows, and storm shutters were of gun metal. The windows of the watch or service room, immediately under the lantern, were specially arranged for admitting air to the lantern, and for regulating the ventilation, in all ordinary weather. The supply of air was admitted by a valve at the upper part of the window, so as to pass above the head of the lightkeeper on duty, and upwards through an iron grating surrounding the lantern floor.

The lantern was one of the cylindrical helically-framed type, designed by the author, and adopted by the Trinity House. It was manufactured by Messrs. S. Hodge and Sons; while the curved plate-glass for glazing it, and the dioptric apparatus, were manufactured bp Messrs. Chance Brothers and Co. The instrument was probably the most perfect for the purpose that had yet been constructed. With the view of giving the Wolf Light a perfectly distinctive character, a revolving dioptric light of the first order, showing alternate flashes of red and white at half minute intervals, was resolved upon. This arrangement involved the consideration of the important question, which did not appear to have been previously determined with accuracy, of disposing in each beam the relative proportion of light to allow for the loss in the red beams by passing through a ruby glass medium, and producing at all distances at which the light could be seen, with variable states of the atmosphere, flashes of nearly the same strength. The investigation of the subject was entered into by Professor Tyndall, the scientific adviser of the Trinity House; and as it was one which could not be determined with accuracy by photometric measurement, he, with the author, paid a visit to the Rock Lighthouse, near Liverpool, which had a catoptric revolving light showing one red flash succeeded by two of white at intervals of one minute, and inquiries and observations were made on this light at the Point of Air Lighthouse, at a distance of 11⅓ miles, and at the Great Ormes Head Lighthouse, at a distance of 30½ miles. Experiments with red and white lights were also made in the experimental lighthouse of the Trinity House at Blackwall, and observations on these were taken from a station in Charlton, at a distance of 2 miles. From these practical tests it was determined that the quantity of light to be appropriated to the red beam should be to that of the white in the ratio of 5,275 to 2,250, or as 21 to 9 nearly. The apparatus had sixteen panels of refractors and lower prisms, and eight panels of upper prisms, to the circle. Eight panels of refractors and lower prisms of 18° each were appropriated to eight beams of white light; and eight panels of refractors and lower prisms of 27° each, together with the eight panels of the upper prisms of 45° each, to eight beams of red light. The colour was produced by ruby glass placed in front of the panels, and revolving with the apparatus. The illuminating power of each beam sent from the apparatus was estimated at 2,250 French units.

The details were then given of the work accomplished on the rock during the eight seasons of 1861 to 1869 inclusive, from which it appeared that a total of two hundred and sixty-six landings had been effected, when the operations were proceeded with for eighteen hundred and nine and a half hours, or one hundred and eighty-one days of ten hours each for the erection of the tower. The light was exhibited on the 1st of January, 1870, and had since been continued with regularity every night from sunset to sunrise.

The total cost of the undertaking, including the lantern, the illuminating apparatus, cost of workyard at Penzance, vessels, and all incidental expenses, might be taken at £62,726. Considering the exceptional difficulties of the work, it was thought that this cost would compare favourably with any similar work that had yet been executed.

The average number of persons of the various classes employed at the lighthouse was seventy. It only remained to add that, on the death of Mr. Walker, in October, 1862, the author was appointed Engineer to the Trinity House, when Mr. W. Douglass, M. Inst. C.E., succeeded him as resident engineer. On Mr. W. Douglass leaving last year to take charge of a similar work on the Great Basses Rock, Ceylon, the completion of the Wolf Lighthouse was entrusted to Mr. M. Beazeley, M. Inst. C.E., the assistant engineer, who was also proceeding with the erection of the Longships Lighthouse.

DESCRIPTION OF THE LINE AND WORKS OF THE SAN PAULO RAILWAY IN THE EMPIRE OF BRAZIL.

By Mr. D. M. Fox, M. Inst. C.E.

Allusion was in the first instance made to the history of the enterprise, from which it appeared that the concession granted to the Baron de Mauá and other distinguished Brazilians was for a line of railway commencing at Santos, passing close by the city of San Paulo, and terminating at the town of Jundiahy, a distance of about 88 miles, with a guarantee of 7 per cent. interest on a maximum capital of £2,000,000 for a period of ninety years, and a right of preference for continuing the line to Rio Claro, a further distance of 80 miles. In 1856, Mr. Brunlees, M. Inst. C.E., became the Engineer-in-chief, by whom the author was appointed principal resident engineer to make the preliminary surveys, and ultimately to take charge of the works. In 1860, a contract was entered into with Messrs. Robert Sharpe and Sons, who undertook to acquire the land, execute the works and buildings, and supply all rolling stock and plant for £1,745,000. A period of eight years was allowed for the completion of the works; but the line was opened for traffic ten months before the expiration of the contract time, and for this expedition a bonus of £43,750 was paid to the contractors, who also received £72,917 on account of extra costs of stations, &c.

An account was then given of the physical characteristics, productions, climate, &c., of the province, as well as of the geological formation of the district through which the line passed, the climate of the plain near the sea level, and that of the high lands above the Serra, which were distinct as regarded temperature, moisture, and rainfall.

Proceeding next to a description of the engineering features of the line, it was stated that the railway ran over low swampy ground for a distance of 13½ miles, from Santos to the foot of the Serra do Mar, a precipitous escarpment running parallel to the sea coast, in a direction at right angles to the railway, and rising abruptly to a minimum height of 2,600ft. above the sea level. At first it was proposed to lay out a locomotive line over the Serra, but with a view to shorten the ascent and to enable the line to be made within the prescribed sum, it was determined to adopt inclined planes of 1 in 10, to be worked by stationary engines, and these inclined planes, and the mode of working them, were the chief points of interest in the undertaking.

From the summit of the Serra to Jundiahy, a distance of 68 miles, the line crossed a succession of short ridges and valleys, with occasional deep cuttings and embankments. The steepest gradient was 1 in 40 for $1\frac{1}{2}$ mile, at the summit of which a tunnel, 650 yards in length, was unavoidable. This tunnel was driven in part through mica schist of a hard and coarse description, with large quantities of quartz and veins of trap intersecting the rock. In the cutting at the northern approach to this tunnel, a slip or landslide on a large scale threatened to endanger the stability of the line. It was temporarily overcome by driving heavy piles along the face of the slip, with transverse stretchers, placed about 3ft. under the rails, on which broken stone was laid. The movement however continued, and eventually a solid invert of stone was constructed, for the whole width of the formation, under the road-bed in lengths of 8ft., without interfering with the traffic. The piles were then cut down, and a retaining wall was built.

The length of the inclines was about 5 miles, the rise being 2,557ft. above the foot of the Serra. There were four inclines, each with a gradient of 1 in 9·75, and 6,388, 5,852, 6,876, and 7,017ft. long respectively. At the top of each incline there was a bank head, about 250ft. in length, with an inclination of 1 in 75 downwards, where the stationary engines were placed. The radii of the curves ranged from 30 chains to 80 chains. The earth-works were very heavy; in some instances the cuttings and embankments being 75ft. and 95ft. in depth on the centre line, and, owing to the steep cross section and the treacherous nature of the ground, the slopes of the cuttings on the upper side, although never flatter than $1\frac{1}{2}$ to 1, were often 330ft. in length, whilst the inferior slopes of the embankments were of corresponding extent. Nearly all the banks were secured by heavy dry-stone retaining walls. Earthworks of this nature were subject to extensive and sudden slips from the mountain side, and embankment after embankment was carried away during construction, sometimes after completion to the formation level. The only effectual mode of stopping these slips, was, by a thorough system of drainage, searching for and gathering all the water on the upper side of the railway, and conducting it across the line in pitched channels set in cement; by pitching the entire surface of the inferior slopes of all embankments, thus preventing wash; and by draining the upper slopes of the cuttings, and securing the same by massive retaining walls. These measures had been so far successful that, during the two last wet seasons, not a single slip occurred on the Serra works. An extensive slip in one of the largest cuttings, during the term of maintenance, was cleared out by the agency of water. A considerable mountain stream was diverted into the cutting, and as many men as could be crowded on pulled down the soil, others working it up; the force of the water on the incline of 1 in 10 rapidly carried the soil away, leaving behind the stone, which was available for pitching the banks, &c. At the foot of the fourth incline a chasm was crossed by an iron viaduct, 705ft. in length, and consisting of ten spans of 66ft. each, and one of 45ft. The greatest depth from the rail level to the ground was 185ft. Each pier was composed of eight cast iron columns, bolted down to a base of solid ashlar masonry, while the superstructure consisted of four wrought iron lattice girders. No scaffolding was used during the erection. An iron wire rope was stretched across the chasm, and piece by piece of the columns was lowered into its place, by means of a block pulley, running along the rope with the necessary tackle. The piers were thus run up simultaneously and independently of each other. The danger of their being blown down when they reached a certain height, by the furious winds to which the locality was subject, was guarded against by laying a balk 66ft. long from pier to pier about the mid-height of the structure, which, with a temporary hand rail, served as a bridge for the men engaged on the work. The girders were erected by means of a crane, with a jib reaching over half the span, mounted on a suitable frame and wheels. On the completion of the first pier, the girders were placed in position from the abutments. The road was then made good over this span, and the crane was moved to the first pier, when the girders were deposited on the second span, over which the road was laid; and this process was continued until the viaduct was completed. The structure was built on a curve of 30 chains radius, and on the incline of 1 in 9·75. The weight of wrought iron in the girders and piers was 562 tons, and of cast-iron in the columns 480 tons. The erection of the iron work was not fairly commenced until March, 1865, and the first train passed over the viaduct on the 2nd of November in the same year.

The inclines were worked by what was known in the North of England as the 'tail end system,' and were thus partially self-acting, wagons being attached to each end of the rope, and raised and lowered simultaneously. The arrangement of the rails was peculiar. On the lower half of each lift an ordinary single line was laid, and on the upper half (above the passing place) three rails were laid, forming a double road road with the centre rail common to both. Exactly half way on each lift, the single line of the lower half and the three rails of the upper half branched out into a double line of way, of sufficient length for the up and down trains to pass, with a 5ft. space between the tracks. The switches at the lower end were self-acting. This arrangement enabled two lines of pullies for carrying the ascending and descending part of the rope to be laid down above the passing place, whilst on the lower half a single line of pullies only was required. At the bank heads three separate lines of way, about 250ft. in length, were provided, the up traffic being alternately run on to one or the other of the side lines, the down traffic being always worked on the centre road. These lines were laid to a gradient of 1 in 75, which was sufficiently steep to allow the wagons to trail the rope out from the engine. The ropes were 4in. in circumference, and were of steel wire. They were tested to 35 tons breaking strain, the maximum working load, as shown by the dynamometer, being from 4 tons to $4\frac{1}{2}$ tons. Their duration was about two years. The ropes ran in light pullies of wrought-iron, with a cast-iron core 12in. in diameter, placed from 5 yards to 7 yards apart on the curves, and 10 yards apart on the straight lines. Extra strong and carefully made sockets were fixed to each end of the rope, with swivels to allow for undue twist in the rope to be worked out. The ropes passed to the engines round horizontal pullies 10ft. in diameter. The winding machinery at each bank head consisted of a pair of 150 nominal h.p. high pressure horizontal engines. The cylinders were 26in. in diameter, with a stroke of 5ft., and were run at a speed of 22 revolutions per minute, with 30lbs. pressure of steam in the cylinders. Motion was given to the rope by means of friction gearing, consisting of two pullies of 10ft. in diameter, the upper one, fixed on to the fly-wheel shaft, having three grooves, and the lower one, running loose, with two grooves, round which the rope was passed in the form of the figure 8. The engines were fitted with a powful break round the fly-wheel, and with an indicator, which showed the driver the position of the train on the incline. Special break-wagons went up and down with every train. The draw bars were movable, so that by raising and lowering them according to the weight of the train, the rope could be made to enter the pullies on the curves with certainty. In addition to the ordinary break-block acting on each wheel, and worked in the usual manner, there was a specially designed safety break, which clipped the rails, and by means of which, in case of emergency, a train could be brought to a standstill in a length of a few yards. The pair of levers which formed the 'clip' were worked by means of a right and left screw turned by a wheel, four revolutions of which screwed the break, so as firmly to grip the rails. The 'clips' when not in use where suspended over the rails by a balance weight, being kept in their places by guide blocks working in iron plates, and were lowered in a moment for action by pressing a lever with the foot. In addition to their value as a safety break, the 'clips' had often to be used in misty weather, when the rails were greasy on the bank heads, in order to pull up the train at the right place. Telegraphic signals were used in working the inclines, and each lift was also provided with a draw wire signal, by means of which the guards in charge of the train could communicate with the engine house, and stop the train at any part of the road. The load at present was limited to three carriages or wagons, besides the special break van to which the rope was attached. The weight of three loaded wagons was about 34 tons, and the break van 6 tons, making a total weight of 40 tons as the maximum load, of which 21 tons was paying load. The time occupied on each incline was about fifteen minutes, or one hour for the whole ascent of 2,550ft. As four trips could thus be made in the hour, twenty four wagons containing 168 tons could be raised and lowered per hour, or two hundred and forty wagons with 1680 tons of paying load per day of ten hours. The whole ascent could easily and safely be made in three quarters of an hour, thus increasing the capacity of the inclines 25 per cent. Since the opening of the line on the 6th February, 1867, the inclines had been worked without accident to either passenger or goods train.

Details were given of the various works of art on the line, of the permanent way, of the locomotives and rolling stock, of the materials of construction obtainable in the province, of the labour available for the works, and of the wages paid to various classes of artisans.

The total cost for works, stations, land, rolling stock, fixed machinery, engineering, and administration, was stated to have been £24,040 per mile, or including the extra capital to pay 7 per cent. interest during construction £31,570 per mile. The receipts for the half-year ending June 30th, 1869, amounted to 1262 contos of reis, and the working expenses to 447 contos of reis, being 35·46 per cent. of the receipts. It was difficult to convert these sums satisfactorily into £. s. d. sterling, owing to the depreciated and fluctuating state of the currency. Had exchange been at par, the net revenue would have been sufficient to pay 3·46 per cent. for the half year on the total guaranteed capital; but at the current rate the equivalent in sterling was equal only to about 2·43 per cent. The depreciated currency likewise added to the working expenses, by increasing the cost in milreis of coal and of all stores from England paid for in sterling. These satisfactory results, no doubt, were in a measure owing to the remunerative tariff; but it must be borne in mind that, in addition to the steep locomotive gradients, all the traffic had to be raised and lowered 2,550ft., for which service the company were only entitled to receive the freight due to 5 miles of level line.

In an appendix, comparative results based on actual experience were given, showing how the Serra inclines were costly to work per mile, and that the traffic, at locomotive rates, was conducted at a loss; but it also appeared that the traffic was worked at a considerably less total cost, and more rapidly, by the steep fixed inclines, than it would have been by means of a locomotive line of 1 in 40, involving a development of 20 miles in length, on the steep slopes of the Serra do Mar, and the cost of which for works alone would probably have amounted to £1,500,000.

At the meeting on the 1st inst., Mr. Charles B. Vignoles, F.R.S., President, in the chair, twenty-three candidates were balloted for and declared to be duly elected, including ten members, viz.:—Messrs. Horatio Brothers, Engineeer to the Equitable Gas Company, Pimlico; Richard Spelman Culley, Engineer-in-Chief of the Telegraph Department, General Post Office; John Gwynne, Hammersmith; Robert Handcock, Sydney, N.S.W.; Samuel Keefer, Brockville, Canada; Charles Martin, B.A., Cork; William Mills, Engineer to the London, Chatham. and Dover Railway; James Price, Engineer to the Midland Great Western and the Great Northern and Western (of Ireland) Railway Companies; Edward James Reed, C.B., the Chief Constructor of the Navy; and Clifford Wigram, Blackwall. Thirteen gentlemen were elected Associates, viz.: Messrs. John George Crampton, Westminster; Henry James Galton, B.A., Engineer's Office, Trinity House; Henry James Burford Hancock, Temple; Geo. Hodson, Surveyor to the Loughborough Local Board of Health; Henry Joll, P.W.D., Government of India: William George Laws, Newcastle-upon-Tyne; Richard

Longlands, Resident Engineer, East Indian Railway; John Marshman, General Manager of the Railways of Canterbury, N.Z.; Wm. Morris, Resident Engineer of the Kent Waterworks, Plumstead; William Powell, Resident Engineer, Harbour Works, Isle of Man; Major Francis Ignacio Rickard, Government Inspector of Mines for the Argentine Republic; Captain Frederick Smith Stanton, R.E., Officiating Consulting Engineer for Railways in the Provinces of Oudh and Rohilkund, India; and Mr. George Hunter Tait, Executive Engineer, Rajputana (State) Railway, India.

ON THE WORKING OF STEAM IN COMPOUND ENGINES.

By W. J. MACQUORN RANKINE, C.E., LL.D., F.R.S.

1. PRINCIPAL KINDS OF COMPOUND ENGINES.

By a compound steam engine is meant one in which the mechanical action of the steam commences in a smaller cylinder and is completed in a larger cylinder. Those cylinders are respectively called, for convenience, the high-pressure cylinder and the low-pressure cylinder. Two classes of compound engines will be considered—first, those in which the steam passes directly or almost directly from the high-pressure to the low-pressure cylinder, the forward stroke of the latter cylinder taking place either exactly or nearly at the same time with the return stroke of the former cylinder; and, secondly, those in which the steam, on its way from the high-pressure to the low-pressure cylinder, is stored in a reservoir, so that any convenient fraction of a revolution (such, for example, as a quarter revolution) may intervene between the ends of the strokes of the cylinders. As to the latter class of engines, reference is made to a paper by Mr. E. A. Cowper in the "Transactions of the Institution of Naval Architects," for 1864, page 241. Sometimes, especially in the first class of compound engines (those without reservoirs), there are a pair of low-pressure cylinders whose pistons move together, and which act like one cylinder divided into two parts.

2. ADVANTAGES OF COMPOUND ENGINES.

As regards the theoretical efficiency of the steam, the compound engine possesses no advantage over an engine with a single cylinder of the dimensions of the low-pressure cylinder working with the same pressure of steam and the same rate of expansion. The advantages which it does possess are the following —First, in point of strength, the action of the steam when at its highest pressure takes place, in the compound engine, upon a comparatively small piston, thus diminishing the amount of the greatest straining force exerted on the mechanism and framing; secondly, in point of economy of heat and steam, in a single-cylindered engine it is necessary, in order to prevent liquefaction and re-evaporation of the steam, and consequent waste of heat, that the whole metal of the cylinder should be kept, by means of a steam jacket, at a temperature equal to that of the steam when first admitted; whereas, in a compound engine, it is the smaller or high-pressure cylinder only which has to be kept at so high a temperature it being sufficient to keep the larger or low-pressure cylinder at the temperature corresponding to the pressure at which the steam passes from the high-pressure to the low-pressure cylinder. Thirdly, in point of economy of work: the whole of the force exerted by the piston rod upon the crank in a single cylindered engine takes effect in producing friction at the bearings; whereas, in compound engines, the mechanism can be so arranged that the forces exerted by the piston rods on the bearings shall, to a certain extent, balance each other, thus diminishing the friction. When there are a pair of low-pressure cylinders with a high-pressure cylinder between them (as in the engines of H.M.S. *Constance*, by Messrs. Randolph, Elder, and Co.) the balance can be made almost perfect. These remarks apply not only to the forces due to the pressure of the steam, but to those produced by the reaction or inertia of the pistons and of the masses which move along with them. The advantages which have been stated are obviously greatest with high rates of expansion.

3. COMBINATION OF DIAGRAMS.

When the diagrams of the high and low-pressure cylinders of a compound engine are taken by means of one indicator they have the same length of base; and when arranged in the customary way for inspection they present appearances which are represented in Fig. 1 for engines without reservoirs, and in Fig. 2 for engines with reservoirs. In each figure A A is the atmospheric line, O P the zero line of absolute pressure, and the length O P on that line is the common length of the diagrams of both cylinders, as originally drawn. The diagram of the high-pressure cylinder is represented in Fig. 1 by C D K H, and in Fig. 2 by C D K L; that of the low-pressure cylinder, as drawn by the indicator, is represented in Fig. 1 by *k i h*, and in Fig. 2 by *l i g h*. In combining the diagrams of the two cylinders into one diagram, it is to be borne in mind that when the area of a diagram is considered as representing the work done by the steam on the piston at one stroke, the length of the base of the diagram is to be considered as representing the *effective* capacity of the cylinder: that is, the space swept through by the piston at one stroke. Hence, in order to prepare the diagram of the low-pressure cylinder for combination with that of the high-pressure cylinder, the lengths of its base, and of every line in it parallel to its base, are to be increased in the ratio in which the effective capacity of the low-pressure cylinder is greater than that of the high-pressure cylinder. (When there are a pair of low-pressure cylinders combined with one high-pressure cylinder, they are equivalent to one low-pressure cylinder of double the capacity). On each of the Figs. 1 and 2, then, then, the base O P is, in the first place, to be produced to B, making O B greater than O P in the proportion above mentioned. To complete the preparation of the low pressure diagram draw, in each case, a series of lines across it parallel to the base O B, such as the dotted lines in each

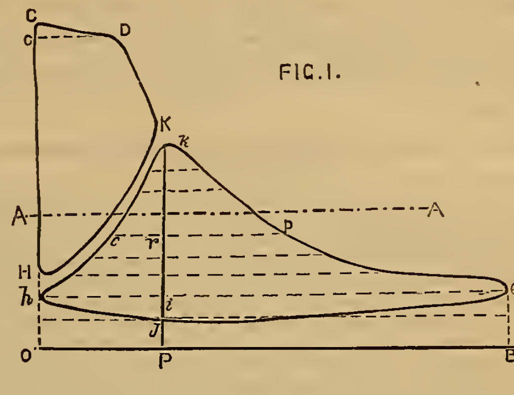


FIG. 1.

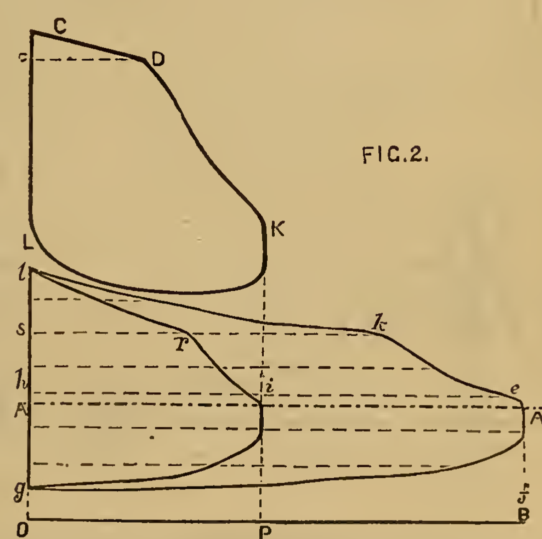


FIG. 2.

figure, of which one is marked *h i e*. Let *c* denote the ratio O B ÷ O P. Then, in the case of an engine without a reservoir, Fig. 1, draw P *k* perpendicular to O B, cutting all the parallel dotted lines, and on each of those lines (such as *s r q*) lay off $s\,q = c \cdot r\,s$. A curve *k q e j*, drawn through the points, such as *q*, thus found, will be the required boundary of the enlarged low-pressure diagram *k q e j h s k*, which, being joined on to the high-pressure diagram C D K H, makes the combined diagram. When the engine has a reservoir, draw O *l* (Fig. 2) perpendicular to O B, and crossing all the dotted lines, and on each of those lines (such as *s r k*) lay off $s\,k = c \cdot s\,r$. A curve *l k e f g*, drawn through the points, such as *k*, thus found, will be the required boundary of the enlarged low-pressure diagram, which, being joined on to the high-pressure diagram, C D K L, makes the combined diagram. In a theoretically perfect engine, in which the steam passed from the high-pressure to the low-pressure cylinder without change of pressure or temperature, the two diagrams would join exactly at the boundaries K L and *k l* in Fig. 2, or K H and *k h* in Fig. 1, so as to form one diagram identical with that produced by the same quantity of steam working between the same limits of pressure in the large cylinder only. But in actual engines there is sometimes a gap between the high and low-pressure diagrams, as in the Figs. 1 and 2; and sometimes, when the steam reservoir is heated, they overlap each other.

4. Rates of Expansion.

In Figs. 1 and 2 let D be the point where the cut-off takes place in the high-pressure cylinder; draw D c parallel to B O; then $\frac{OP}{cD}$ is the rate of expansion in the high-pressure cylinder; $\frac{OB}{OP}$ is the total increase of volume in passing from the high-pressure to the low-pressure cylinder; and the product of those quantities, $\frac{OP}{cD} \cdot \frac{OB}{OP} = \frac{OB}{cD}$, is the total rate of expansion.

5. Construction of Theoretical Expansion-Diagrams for Proposed Engines.

In constructing the theoretical diagram of a proposed steam engine certain well-known assumptions are made in order to simplify the figure and the calculations founded upon it. In the first place, the pressure of the steam during its admission is assumed to be constant, so that the uppermost boundary of the diagram, as in Figs. 4 and 5. is a straight line C D, parallel to the zero line O B, the height O C representing the absolute pressure of admission. Secondly, the back pressure is assumed to be constant; so that the lower boundary of the diagram also is a straight line F G parallel to O B, the height O G representing the mean absolute back pressure, as estimated from the results of experience. Thirdly, it is commonly assumed that at the beginning of the forward stroke the pressure rises suddenly from the back pressure to the pressure of admission, so that the first end-boundary of the diagram is a straight line G C perpendicular to O B. Fourthly, it is assumed that at the end of the forward stroke the pressure falls suddenly from the pressure at the end of the expansion (or *final pressure*) to the back pressure, so that the second end-boundary of the diagram, there is assumed a line of the hyperbolic class. Thus the area of an assumed theoretical diagram of the work of the steam in a proposed engine is made up a hyperbolic area C D E H, and a rectangular area E F G H. The form of the expansion curve depends on a number of circumstances, such as the initital pressure and temperature of the steam, the proportion of water (if any) admitted along with it in the liquid state, the communication of heat between the steam and the metal of the cylinder, and the communication of additional heat to the steam during its expansion by the help of a steam jacket. Writers on thermodynamics have determined the exact form of that curve in various cases, such as that of steam originally dry, expanding in a non-conducting cylinder; that of steam originally containing a given proportion of moisture expanding in a non-conducting cylinder; that of steam originally dry supplied during the expansion with heat just enough to keep any part of it from condensing; that of steam supplied during the expansion with heat sufficient to keep it at a constant temperature. For most practical purposes the common hyperbola forms a good approximation to the true expansion curve, and it is convenient because of the simplicity of the processes for finding its figure, whether by calculation or by construction. To find by calculation the series of absolute pressures corresponding to a given series of volumes assumed by the steam, on the supposition that the expansion curve is a common hyberbola, multiply the initial absolute pressure by the initial volume; divide the product by any one of the given series of volumes; the quotient will be the corresponding absolute pressure. To find a series of points in the common hyperbola, in Fig. 3, draw the two axes O X and O Y perpendicular to each other; O X to form a scale of volumes, and to represent the zero line of absolute pressure; O Y to form a scale of absolute pressures. On O X lay off O A to represent the initial volume of the steam, also O B′, OB″, &c., to represent a given series of volumes occupied by the same steam during its expansion. On O Y lay off O C to represent the initial pressure of the steam. Through C draw the straight line C a b' b'', &c., parallel to O X, and through the points A, B′, B″, &c., draw the series of straight lines A a, B′ b', B″ b'', &c., parallel and equal to O C. From O draw the series of diverging straight lines O b', O b'', &c., and mark the series of points C, C″, &c., where they cut A a. From these points, and parallel to O X, draw the series of straight lines C′ D′, C″ D″, &c., and mark the series of points D′ D″, &c., where they cut the series of straight lines B′ b', B″ b'', &c. These points, together with the point a, will be points in the required hyperbola, a D′ D″, &c., which is taken as an approximation to the expansion curve.

FIG. 3.

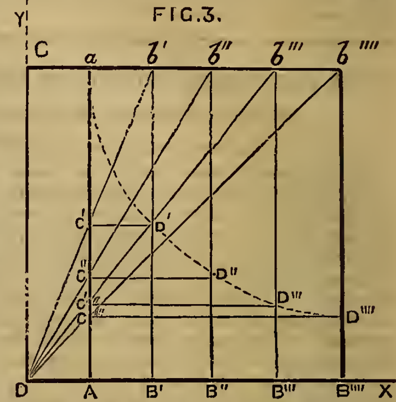


FIG. 4.

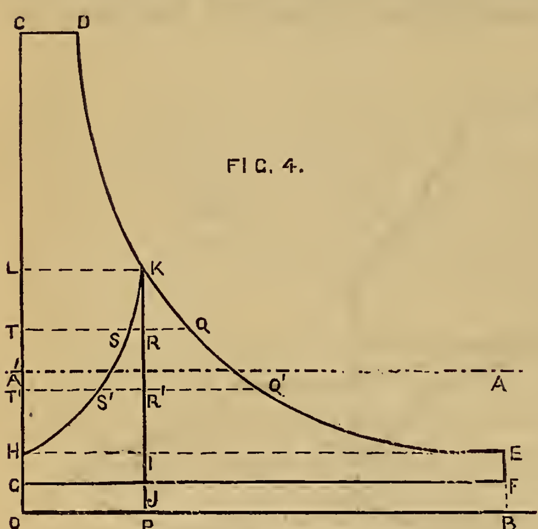
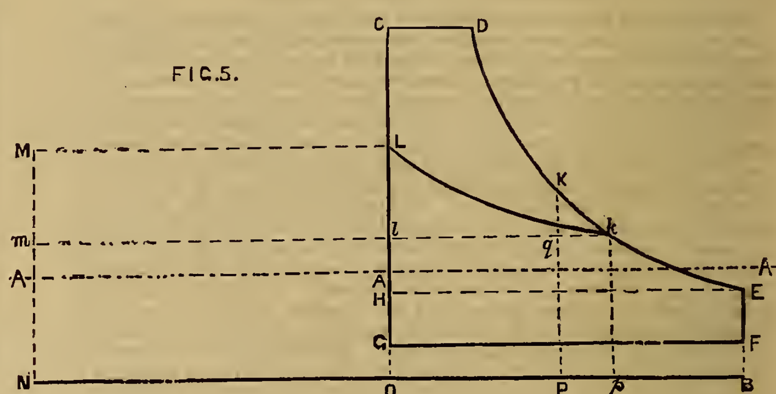


FIG. 5.



6. Calculation of mean absolute pressure and of indicated work in a Theoretical Diagram.

Suppose that in Fig. 3 O B⁗ represents the final volume of the steam so that D⁗ is the end of the expansion curve, and that B⁗ D⁗ represents the final absolute pressure. The intermediate volumes O B′, O B″ &c., are to be so chosen that the points B′, B″, &c., shall divide A D″, into an even number of equal intervals. Multiply the series of absolute pressures represented by A a, B′ b', &c., by "Simpson's multipliers," which are, for the initial and final pressures, 1; and, for the intermediate pressures, 4 and 2 alternately; so that, for example, for four intervals, and five absolute pressures, the multipliers are 1, 4, 2, 4. 1; for six intervals, and seven absolute pressures, 1, 4, 2, 4, 2, 4, 1, and so on. Add the products together; divide the sum by three times the number of intervals. Multiply the quotient by the rate of expansion; the quotient will be the required mean absolute pressure, nearly.—*Example:* Rate of expansion, 5; expansion divided into 8 equal intervals; initial absolute pressure, 37·8lb. on the square inch.

Absolute pressure.		Multipliers.	Products.
Initial	37·80	1	37·80
Intermediate	37·8 × $\frac{2}{3}$ = 25·20	4	100·80
	37·8 × $\frac{1}{2}$ = 18·90	2	37·80
	37·8 × $\frac{2}{5}$ = 15·12	4	60·48
	37·8 × $\frac{1}{3}$ = 12·60	2	25·20
	37·8 × $\frac{2}{7}$ = 10·80	4	43·20
	37·8 × $\frac{1}{4}$ = 9·45	2	18·90
	37·8 + $\frac{2}{9}$ = 8·40	4	33·60
Final	37·8 × $\frac{1}{5}$ = 7·56	1	7·56

Divide by 8 intervals × 3 = 24	) 365·34 sum
Quotient	15·2225
Multiply by rate of expansion 5 − 1	4
Product	60·89
Add initial absolute pressure	37·80
Divide by rate of expansion	5) 98·69 sum
Mean absolute pressure................ nearly	19·738

The remainder left after subtracting the back from the mean absolute pressure is the *mean effective pressure*, which, being multiplied by the area of the piston and by the distance moved through by the piston in a given time gives the indicated work of the steam in that time.*

7. Theoretical Combined Diagrams.

By the process described in the preceding section there may be constructed the approximate theoretical diagram of steam working with a given initial pressure and a given rate of expansion, and against a given mean back pressure. In the case of a proposed compound engine, that theoretical diagram is to be regarded as the combined diagram of the two cylinders, and it is to be divided into two parts, representing the parts of indicated work done in the two cylinders respectively. In each of the two figures, 4 and 5, the theoretical combined diagram is represented by C D E F G, O C being the initial, and B E the final absolute pressure, O G = B F the mean back pressure, A A the atmospheric line, O B the zero line of absolute pressure, H E = F G = O B the effective capacity of the large cylinder, C E the initial volume of steam admitted per stroke, and $\frac{\text{E H}}{\text{C D}}$ the total rate of expansion. The dividing line which marks the boundary between the high-pressure and low-pressure diagrams is represented in Fig. 4 by K H, and in Fig. 5 either by *k* L, or by *k l*, or by some line near those lines, as will afterwards be more fully explained.

8. Theoretical Diagrams of a Compound Engine without a Reservoir.

When the steam passes directly, without loss of pressure or of heat, from the high-pressure to the low pressure cylinder, the dividing line of the theoretical compound diagram is found by the following process. In O B lay off O P to represent the effective capacity of the high-pressure cylinder. Through P, parallel to O C, draw the straight line P J K, cutting the back pressure line in J, and the expansion curve in K; then K will be one end of the dividing line. Through the lower end E of the expansion curve, and parallel to B O, draw E H, cutting O C in H; then H will be the other end of the dividing line. To find intermediate points, draw, parallel to O B, a series of straight lines, such as T R Q, T′ R′ Q′, across the part of diagram which lies below the point K, and in each of those lines, for example in Q R T, lay off R S, bearing the same proportion to R Q that P O bears to P B; the points thus marked, such as S and S′, will be in the required dividing line K H. The areas of the two parts of the theoretical diagram, C D K H, and K E F G H, being measured by ordinary methods, will show the comparative quantities of work done in the high-pressure and low-pressure cylinders respectively. The advantages of the compound engine in point of diminution of stress and friction are most fully realised when those quantities of work are equal; that is, when the line K H divides the area C D E F G into two equal parts; for then the mean values of the forces exerted through the two piston rods are equal; hence the proportion borne by the effective capacity of the high-pressure cylinder to that of the low-pressure cylinder ought to be chosen so as to realise that condition as nearly as possible. An exact rule for that purpose would be too complex to be useful for practical purposes. The following empirical rule has been found by trial to give a good rough approximation to the required result in ordinary cases of compound engines without reservoirs: Make the ratio in which the low-pressure cylinder is larger than the high-pressure cylinder equal to the square of the cube root of the total rate of expansion; for example, if the total rate of expansion is to be 8, let the low-pressure cylinder be four times the capacity of the high-pressure cylinder (this rule was first given in "Shipbuilding, Theoretical and Practical," page 275).

When a table of squares and roots is at hand, look for the total rate of expansion in the column of cubes, the required ratio will be found in the column of squares.

9. Theoretical Diagrams of a Compound Engine with a Reservoir.

To realise theoretical perfection in the working of an engine with an intermediate steam reservoir, that reservoir should be absolutely non-conducting, so that the steam may pass from it into the low-pressure cylinder at exactly the same pressure and volume at which it is received from the high-pressure cylinder. Supposing this condition to be realised, let O *p* in Fig. 5 represent the volume of steam admitted into the low-pressure cylinder at each stroke, so that $\frac{\text{O B}}{\text{O } p}$ is the rate of expansion in that cylinder; then O *p* will also represent the capacity of the high-pressure cylinder, and $\frac{\text{O } p}{\text{C D}}$ will be rate of expansion in it; and if *p k* be drawn parallel to O C so as to cut the expansion curve in *k*, this point will be one end of the required dividing line. To find other points on that line under the same theoretical conditions, combined with the supposing that the forcing of the steam into and its delivery out of the reservoir take place at separate times, produce B O, making O N of a length representing the capacity of the reservoir; then in O C lay off O L greater than *p k*, in the proportion in which N *p* is greater than N O; L will be the other end of the dividing line *k* L, which line will be an expansion curve for steam of the initial volume represented by N O = M L, and initial absolute pressure represented by O L = N M, and may be constructed by the method of sec. 5. The high-pressure diagram will be C D *k* L, and its lower boundary, *k* L, will represent the increase of pressure during the process of forcing the steam from the high-pressure cylinder into the reservoir; the low-pressure diagram will be L *k* E F G, and its upper boundary L *k* will represent the diminution of pressure during the process of delivering the steam from the reservoir into the low-pressure cylinder. But, in reality, the entrance of the steam into and its delivery from the reservoir take place partly at the same time, and the metal of the reservoir abstracts heat from the entering steam, and gives heat back to the escaping steam; the practical result (as shown by the diagrams published in Mr. Cowper's paper already referred to) being that the pressure of the steam in the reservoir is nearly constant, so that the upper boundary of the low-pressure diagram nearly coincides with a straight line, *l k*, parallel to O B. The same straight line also coincides nearly with the lower boundary of the high-pressure diagram.

In the engines experimented on by Mr. Cowper, the effective capacity of the high-pressure cylinder was somewhat smaller than the volume of steam admitted at each stroke into the low-pressure cylinder, being represented, for example, by O P instead of by O *p*; and the final pressure P K in the high-pressure cylinder was greater than the pressure in the reservoir.

The high-pressure diagram was thus made to resemble C D K *q l* in Fig. 5, leaving a sort of *notch*, K *q k*, between it and the low-pressure diagram *l k* E F G; but it appears that this loss of area was compensated by the effect of the steam jacket enveloping the reservoir, which, by imparting additional heat to the steam, caused the low-pressure diagram to be of a fuller form in the part *k* E than that bounded by the theoretical curve.*

In this case a rough approximation to an equal division of work between the high and low-pressure cylinders may be obtained by making the rate of expansion in the low-pressure cylinder equal to the square root of the total rate of expansion.

GENERAL NOTES ON BOILERS AND ON THE PREVENTION OF EXPLOSIONS.

By Henry Hiller, Engineer to the National Boiler Insurance Company.

The following useful remarks are made by Mr. Hiller, at the conclusion of his yearly report containing a list of boiler explosions similar to that given in The Artizan of last month:—

The great loss of life and property reported, in the preceding list and description of explosions, call for special attention. I propose by a comparison of those arising from various causes, and by remarks thereon, to point out the means of prevention, or at least of the reduction of risk; which will doubtless be of interest to many to whom this report will be supplied, whilst tending to the abolition of some of the objectionable practices, which attend the use of steam in this country.

It will be noted, on referring to the list, that the greater number of explosions occur through defective condition of the boilers; arising from original mal-construction, unskilful setting or fitting up, or through improper or too long usage. Out of the 53 explosions of which I have obtained reliable particulars, fifteen were owing to radical weakness in the construction of the boilers, viz.: weakness of flue tubes, insufficient staying

* A well known formula for the ratio of the mean to the initial absolute pressure is $\frac{1 + \text{hyp. log. } r}{r}$, *r* being the rate of expansion.

* In Mr. Wenham's compound engine (exhibited in 1862) the steam on its way from the high pressure to the low pressure cylinder was heated in tubes passing through a flue. This would still further increase the fullness of the low pressure diagram.

weak manholes, &c.; eleven occurred from defects to which externally-fired boilers are especially and peculiarly liable, and fifteen resulted from the weakened state of the boilers, through corrosion or grooving.

The proportion of explosions through deficiency of water is beyond the usual average, but is still below 17 per cent. of the above 53 cases; whilst the damage by explosions from this cause is usually comparatively slight. In only one instance of the nine herein reported, was material damage done to property. The most disastrous case which occurred, was that of a boiler on board one of Her Majesty's Gunboats, which exploded during a "trial trip," when a large number of engineers and others were assembled about the engines and boilers. The only rupture in the boiler was at the crown of one of the furnace tubes, but the rush of steam, &c., caused the death of eleven persons and serious injury to seven others.

Fusible plugs or other apparatus to avert damage through deficiency of water, are seldom used in marine boilers, although many of these are injured through overheating. If ordinary plugs are objected to, it appears desirable that some other form of alarm apparatus should be attached, so as to prevent damage in case of mistake or neglect. Some of the explosions of stationary boilers would have been prevented, had the furnace tubes been fitted with good fusible plugs, or if a good low-water safety-valve had been attached to the boiler.

The explosion of no less than eleven plain cylindrical boilers through fracture at the furnace seams, &c., calls for especial remark. The unskilful manner in which many of these boilers are worked, and the defective mode in which they are repaired; has been fully referred to in previous reports. With water containing much sediment, it is impossible to prevent the furnace seams being overheated and damaged, and thus new boilers are often fractured after but short service; and the "patching" commences only to be finally completed, in many cases, by explosion. The fractures occurring in these boilers are almost always of a dangerous character, frequently extending a length of several feet through the line of rivet holes, and liable at any time to lead to explosion. Although competent inspection might arrest disaster in many instances, the deterioration of the plates cannot always be easily detected. Six of the exploded boilers were constructed with the plates laid lengthwise, a most objectionable plan, instead of in rings; as the longitudinal seams which are subjected to the greatest strain, are thereby brought over the furnace and thus most exposed to injury. Some of the explosions occurred when the boilers were being re-started after repairs, &c., owing probably to the latter not being carried far enough, or through omitting to cut off the old line of rivet holes, or through excessive straining of the old plate when riveting the new one thereto. When externally-fired boilers are preferred, it would materially conduce to their safety, if the plates were so arranged, that the longitudinal seams would not be over the furnace; whilst the addition of a flue tube or very strong longitudinal stays, would so unite the ends, as to much reduce the risk of disaster in case of fracture at a ring seam; but they can never be so reliable for ordinary service as a well constructed internally-fired boiler, although they may work well for many years, where fed with good water and carefully managed.

The explosions from mal-construction manifest deplorable ignorance or neglect, on the part of those persons who designed or made some of the boilers, and of those who superintended the alterations of the others. Alterations are continually being made, and unfortunately in many cases where flue tubes are removed, as in three of the exploded boilers reported on; the large flat ends, which were previously so well "tied together" by the tubes, are not suitably strengthened; and although the total pressure, on each end, may amount to some sixty or seventy tons, they are left unsupported, except by two or three diagonal rods, insecurely attached by small pins; the inadequateness of which is manifested by their failure. Year after year, cases of this description occur, and it is to be regretted that owners are not convinced thereby of the necessity for proper supervision, and instead of submitting themselves to the guidance of men who work cheaply (?) take steps to obtain good boilers, and avail themselves of the services of those thoroughly acquainted with such matters.

The present unsatisfactory character of coroner's inquests on boiler explosions, owing to the coroners being, in many cases, unable to employ skilled engineers to give evidence; was displayed most forcibly in one instance, where the failure was clearly due to insufficient staying of the end plate, which was blown out. Evidence was given by a boiler maker, who did not account for the explosion, but stated that it "took him by surprise;" and other evidence of similar character being adduced, the coroner was led to remark "that the owners were free from all blame, as they had provided good machinery and competent workmen." A verdict of "Accidental death" was recorded, and the cause of explosion left unexplained.

It is frequently our duty, in reporting on boilers proposed for insurance, to advise additional stays or alterations essential to safety, and numerous instances might be described in illustration. Three two-flued boilers, nearly 7ft. diameter, and working at 50lbs. per square inch, were proposed to us. The ends were quite flat, and attached to the shell by angle iron; the only stays at each end were two very slight gussets attached to a short strip of light angle iron by three rivets each. The owner refused to strengthen them, on the ground of their having worked some years without accident. The proposal was therefore declined. Breeches-flued boilers are met with where the combustion chamber is not suitably stiffened by vertical tubes, others with large flat topped domes or thin plates, unstayed, and the hole in shell full size, much weakening the boiler, &c., &c. In one boiler constructed on the "Galloway" plan, the large oval flue was found made of plates varying from $\frac{7}{16}$ inch down to $\frac{1}{4}$ inch in thickness; the thinnest plates being at the sides, which instead of being semi-circular, were of flattened weak form. On subjecting the boiler to hydraulic test one of these sides collapsed.

The weakness of large flue tubes has been frequently pointed out, and various modes of strengthening, by flanged seams or hoops, T rings, cross tubes, pockets, &c., have been adopted by many first-class makers; but in some districts, especially in Cornwall, where the boilers might be expected to be of superior construction, many are at work with tubes of large diameter unstrengthened in any way; and although collapse from weakness is frequent, the failure is generally erroneously attributed to deficiency of water. At one mine in the district named, three explosions, through weakness of flue tubes, occurred during the last twelve months; all of which might have been prevented, had the tubes been suitably strengthened by any of the means herein referred to. It is of great importance that flue tubes be constructed of circular form; this is best attained by welding the longitudinal joints or by butting the edges of the plates and riveting joint strips thereat. Where tubes are made with the usual "lap joint, it is important that the longitudinal seams should "break joint" in that part of the tube beyond the furnace bridge.

The system of laying the plates longitudinally in flue tubes is objectionable, and should never be adopted.

Suitable manhole beds with planed joint faces assist in making good joints, and thus avoid the annoyance of leakage; whilst the explosions which occur illustrate the necessity for their attachment. The plates at the edge of unstrengthened manholes are frequently found distorted and dangerous, through the great strain applied when screwing up the joint. No bolted joint should be made directly on the boiler. Suitable beds with faced joint, should be provided for all fittings or pipes.

As before noted, the explosions from failure of the outer shells of boilers, through the weakening effect of corrosion, are usually accompanied by most disastrous results; hence it is especially desirable to consider how such catastrophes may be prevented.

Internal corrosion, due to acid contained in the water, may generally be easily discovered on making an inspection of the interior of the boiler, if it be suitably cleaned beforehand. Where practicable, the use of acid water should be discontinued, but if this be impossible, means should be taken to neutralize the acidity before passing the water into the boiler. Carbonate of soda has been used with success in many instance, but it is obvious that, as previously advised, the best course will be in each case, to first subject the water to careful analysis.

External corrosion is most generally met with at the lower part of the boilers, arising from leakage or from external moisture about the seatings; which are too often of such excessive breadth, or of such arrangement, that the condition of the plates cannot be seen. The cases of explosion described, exemplify how essential it is, that the plates, &c., in every part of the flues, should be easily accessible; and the latter should be so arranged, and of such size, that a man may pass along them to make complete inspection of every part; except where the boilers are very small and short, in which case the flues may be so arranged, that the boiler could be examined by passing a light along. Where it is deemed desirable to contract the area of large flues, this should be done by thin temporary walls, which could be removed to allow inspection. Much complication is introduced in the arrangement of the external flues of some boilers, the advantage of which is very doubtful. The breadth of brickwork seatings, or of walls where in contact with the plates, at the lower part of shell; should not exceed 4½ inches, so that if corrosion be going on, it may be readily detected. I have before stated that in some of the instances recorded, the condition of the boilers which exploded was known to those in charge; but owing to their gross ignorance of proper management, and of the causes which lead to explosions, the use of the boilers was continued; and in some of them, clumsy attempts to repair with bolted patches, (a most reprehensible practice) was resorted to.

The two most destructive explosions, occurred to second-hand boilers, viz:—a two-flued one from external corrosion, and the Rastrick boiler from internal corrosion. At the inquest relating to the latter, an engineer witness attempted to ascribe its failure to deficiency of water, but his erroneous evidence was counteracted by that of a gentleman thoroughly conversant with such matters, who attributed the disaster to the bad condition of the boiler; which was, without doubt, the actual cause.

The vertical boilers used in many iron works which are heated from the "puddling" and other furnaces, repeatedly fail and require repairs, their construction also renders it difficult to examine them satisfactorily. A horizontal internally-fired boiler of suitable design, would be much more reliable and satisfactory, whilst the heat from the furnaces might be more fully utilised.

Second-hand boilers should never be purchased unless previously thoroughly examined by some one of special experience.

The hydraulic test is a valuable auxiliary to inspection, but it is frequently applied in such a manner, as to render it valueless, and sometimes positively injurious to the boilers. It is more valuable when used to test the strength of flue tubes, flat surfaces, or irregular forms, than for cylindrical shells; and should never be substituted for careful thorough inspection. Shell plates, much thinned by corrosion, will sometimes resist, without fracture, a comparatively high hydraulic test pressure; although quite unreliable and unfit for ordinary work at a low pressure. Boilers under steam pressure, are also subjected to most severe and varying strains, through unequal expansion; which is the most fruitful source of fractures, whilst hydraulic pressure is uniform in every part of the boiler. This test should never be resorted to except under the superintendence of a competent engineer, who should, before the pressure is applied, gauge and carefully examine every part of the boiler. This examination should be repeated after the pressure has been steadily sustained for about one hour, that any distortion or defect may be noted; and if yielding be apparent, the "permanent set," &c., when water is let out noted. New boilers should always be tested and all made good, before they are bricked in.

The mode in which many boilers are covered at the upper part, by heavy "flagging," &c., is most objectionable, as the plates cannot be seen without removing this cumbersome covering; to which many owners are averse. Numerous instances might be referred to, where the plates at this part have been found most dangerously weakened.

It will be evident from the preceding notes, that careful inspection would have revealed the defects which led to many of the disasters recorded; and that had the owners proposed the boilers for insurance, such suggestions would have been made, as would, if adopted, have averted the explosions. The advantages of connection with this company are forcibly illustrated by the events, &c., of the past year, and will I trust decide many to insure with us. Some proprietors may delay doing so, in the belief that their arrangements are such that they would derive but little advantage. I believe that our system of periodical independent inspection is beneficial in every case where boilers are inspected and reported on by us; especially where we have that co-operation and assistance in the proper preparation of the boilers for examination, &c., which enables us to perform our services satisfactorily; whilst from our special experience in the construction and working of all classes of boilers, we can supply reliable and valuable advice, to those insurers who may desire it. We have had considerable trouble to induce some owners to afford opportunity and make suitable preparation, when we desired thorough inspection of their boilers; but I have pleasure in acknowledging the care and attention manifested in this respect by many firms, by which the inspections were facilitated and the state of the boiler properly ascertained. If the flues are uncleaned, and the plates covered with soot externally, and without sediment or mud internally, it is impossible to examine properly, and the time, &c., expended in making the visit is thus thrown away.

THE ROYAL MINT.

In a report lately issued by Mr. Freemantle and Mr. Rivers Wilson the following recommendations are contained:—

"It has been stated in our memorandum on the Mint, that the present system of assaying is capable of improvement.

"At present all bars ready for coining, and all gold and silver coins, are assayed by two of the non-resident assayers of the Mint, who receive a fee on each assay. This fee was originally 2s. 6d., but in 1868, on the recommendation of the late Master of the Mint, it was increased to 4s. 6d. for the first 2,000 assays in each year; and, calculated on this scale, the average amount of remuneration received by the assayers is £1,278 a year. We propose that the employment of non-resident assayers should be abandoned, and that, instead, a second resident assayer should be appointed, with a salary of £400 to £500 a year, and that he should be assisted by a junior clerk at the usual salary of £100, rising to £250 a year, and an attendant at £70 a year. In the event of a vacancy in the existing office of resident assayer, his successor should be appointed at the same salary of £400 to £500 a year, so that the two appointments may be on a footing of equality. An immediate expenditure of £570 a year would be incurred by this arrangement, and a saving of £700 a year would be effected. From this saving must be deducted the expense of restoring the second assay office, which already exists in the Mint, and the annual cost of the fuel and implements which would be required, but these would be inconsiderable.

Some change also appears desirable in the arrangement for watching the Mint premises. At present a police-sergeant and six constables are employed on this duty at a cost of £600 to the department, and besides the police, five sentries are on duty at night, and three during the day, in the 'military way,' which surrounds the buildings. It would seem desirable to substitute for the police one gate porter, who would be on duty during the day, and two night watchmen, one of whom might act as night porter, and the other as watchman, to patrol the premises, 'tell-tale' dials being, as at present, affixed to various parts of the buildings. The wages of the porter and watchmen would amount to about £230 a year, and a saving would, therefore, be effected of £370 a year.

"Should the above recommendations be adopted, the following reductions of expenditure will have been effected since the beginning of the current year:—

In officers and mechanics' wages	£2,100
In workmen's wages	100
In the Assay Department	700
In the expenses of watching	370
	£3,270

Or, if the Deputy Mastership were abolished, £4,070.

"It should be observed that in our former memorandum we have assumed that the total future expenses of the Mint will amount to £25,000 a year. The expenses for the financial year 1869-70 (exclusive of £15,000 for loss on the re-coinage of worn silver, which does not at present enter into consideration) were estimated at £30,550.

"One other point remains to be noticed, namely, that there would appear to be no reason why the Mint should, as has hitherto been the case, refuse to undertake the execution of coinages for foreign Governments. Many contracts for foreign coinages have of late years been executed at Birmingham, with large profits to the contractor, and it is obvious that the Mint, with the appliances at its command, and the risk to which it may at any time be exposed of being left unemployed, could with advantage undertake such contracts.

"Coinages for foreign Governments are undertaken by some of the Mints in other countries. A coinage for Roumania and another for Egypt have recently been struck at the Paris Mint.

"We would recommend that, for the future, should any offer be made to the Mint to undertake a coinage for a foreign Government, the Master of the Mint should report the circumstances to the Treasury, and should be empowered to make the necessary arrangements for executing the work."

ANGULATED RUDDERS.

It is well known that an angulated target has its face set at an angle favourable to the gliding off of the impinging shot—an angulated rudder has its face convertible to an angle favourable to the retention of the currents of water striking against it, so that where in the ordinary rudder a partial or small amount of work is done and at a slow rate of speed, then in the angulated rudder the greatest amount of power is produced at the highest speed. In these days of rapid water travelling, an efficient steering apparatus for a war vessel, and safeguard to a passenger steamer is of great value and importance. With increased water travelling a necessarily augmented amount of danger exists from collisions, and to avoid such accidents the use of the angulated rudder is suggested, and with apparently so simple and efficient an alteration of the common rudder, it will be unaccountable if steamship owners and builders do not in course of time thoroughly adopt the new system. We are continually hearing of collisions at sea, many of which might have been avoided if efficient steering power were at hand. We say this advisedly, because it would appear that the angulated rudder has been the means of preventing collisions in several cases. Its handiness in vessels of war has been exemplified in the many ships of the Royal Navy, fitted with the Lumley rudder, which is one of the methods of angulation now in use. The difference in its favour, as tested against the rudder of ordinary construction, is very great and highly suggestive of important improvements in the sluggish manœuvring of many war vessels. The demand for increased turning power has produced a supply of expedients. The system of double screw propulsion, is of no general and constant value for steering purposes. It is in the rudder the means of altering direction are found. A resort to the engine-room to steer the ship when an efficient rudder is at hand, is but a blind exposition of a theory, successful perhaps in a carefully arranged and special experiment, but unnecessary, and a loss of time in practice. The power of turning, exhibited by the "water-jet" system, whose apostle, Mr. Ruthven, has, by the way, shown his faith in his creed and his sagacity at the same time, by adapting and introducing Angulated Rudders into his water jet vessels, is interesting in an experimental and particular form, but its practical value in every-day work, is but a dormant and useless affair compared with the power of the rudder itself, which is always ready for use and never-failing.

OPENING OF THE WEST INDIA SOUTH DOCK.

On the 5th ult., at high water, the newly-constructed South Dock, forming an extension of the East and West India Dock Company's range of accommodation for shipping, was formally opened by the admission of a fine new vessel called the *Lufra*, the property of Messrs. Robertson and Co., of Cornhill, which has just been built for them at Aberdeen, and is intended for the China trade. The new dock extends across the Isle of Dogs from Limehouse to Blackwall, and comprises the site of the old City Canal, together with what was formerly known as the East and West India Dock timber pond, affording a water area of no less than 33 acres. There are four pairs of dock gates, the entrance lock being 300ft. in length and 55ft. in width, and at high water spring tides there are 30ft. of water on the sill of the dock. The lock leads to a basin of about six acres in extent, which is divided from the main dock by two pairs of gates, one pair opening towards the basin and the other towards the main dock itself. The whole of these gates are worked by hydraulic machinery, and it is stated that access to and egress from the new dock can be maintained at all conditions of the tide. On the north, or export quay are 16 fine jetties, constructed to afford accommodation for the largest class of merchant ships. There is also a line of quay frontage of fully a mile and a quarter in extent. The whole of the works have been carried out in the most substantial manner under the superintendence of Mr. Hawkshaw, Mr. G. Wythes, of Bickley, being the contractor, and the brickwork having been executed under the supervision of Mr. John Baldwin.

H. M. S. "HOTSPUR."

This powerful armour-clad turret ship was successfully launched on the 19th ult., from the Govan shipbuilding yard of Messrs Robert Napier and Son, of Glasgow. Besides being fitted with a fixed turret, she has an enormously powerful ram projecting from her bows under water. The following are some of her principal dimensions:—Length between the perpendiculars, 235ft.; breadth, 50ft.; depth in hold, 20ft. 1in.; burden, 2,637 18-94 tons builders measurement; and 600 horse-power. This war ship is constructed on a principle that is entirely new in this country, but which was adopted some time ago in connexion with the navy of France. The diameter of the turret, which is pear-shaped, is 31ft. 6in., and 35ft. 9in. from the aft to the fore side. This stationary turret is armed with a 30 ton gun, carrying a 600lb. shot. It is worked on a revolving turn table, the diameter of which is 26ft.; from the two front port holes the gun has a training of 60 deg., and at the side port holes a training of 4½ deg. aft, and 26 deg. forward, so that it is able to fire right forward, and almost, but not quite, right aft. The gun can be elevated 12½ deg. and depressed 7, the recoil being 6ft. 3in. The ram projects about 9ft. below water, and is brought up to a sharp point at a depth of about 8ft. below the water line. There are three decks, the middle one being plated with two thicknesses of iron tapered forward and aft. The engines, which have been made and fitted by the Messrs. Napier, are of the direct acting horizontal description, having two piston-rods to each cylinder, and are fitted with surface-condensers and all the most recent improvements. The boilers, of which there are four, are of the ordinary tubular type, with five furnaces each. The propellers are 14ft. in diameter, on Griffith's plan, with movable blades. In all, six armour clads have been built by the Messrs. Napier, for the British Navy. In 1856 they set afloat the *Erebus*, in 1861 the *Black Prince*, in 1862 the *Hector*, in 1869 the *Audacious* and *Invincible*, and now the *Hotspur*.

AMERICAN RAILWAYS.

It appears that the addition to the railway system of the United States during the past year was 6,588 miles, a total nearly twice as large as in any previous year. The first railway in America was commenced with three miles at Quincy, Massachusetts, in 1827, and the total length is now 48,860 miles, while there are 27,507 miles projected and in progress. The State with the greatest mileage is Illinois, which figures for 7,186 miles, and is followed by Pennsylvania with 6,878, Indiana with 5,331, New York with 4,735, and Ohio with 4,613. California has already 2,307 miles, and is far above some of the older States, such as Louisiana and Mississippi. The State with the least mileage is, of course, the small one of Rhode Island, which figures only for 121 miles. This account of length of roads does not include the second tracks with which most of the leading lines are supplied, nor the sidings and turn-outs. These may be estimated at 25 per cent. of the length of road, and are being added to yearly. Adding these supplementary tracks to the tabulated mileage, the total length of equivalent single track in use is about 60,000 miles, and adding to this the equivalent for the city passenger tracks, to nearly 65,000 miles. As regards works in band it is stated that the new year opened with nearly 300 railroads in process of construction between Maine and California. These, it is estimated, when finished, will represent an aggregate of about 15,000 miles, and great efforts will be made to complete them all within the twelvemonth.

NOTES AND NOVELTIES.

MISCELLANEOUS.

Bronze Coinage.—The cost of material for the bronze coinage is less than £100 a ton; the cost of the workmanship, by contract, is about £50 a ton, and the pence are issued or sold at the price of £448 a ton; showing a profit to the State of £330,000, or equal to about £10,000 annually.

The Pennsylvania Oil Trade.—The statistics of the American Pennsylvania crude oil industry for the past year are now published. The total production of the year was the enormous amount of 4,215,142 barrels, being a daily average of 11,548 barrels. The production of 1868 was 3,715,741 barrels, the increase during 1869 over the previous year thus being 499,401 barrels, the increase per day being about 1,460 barrels.

Exportation of Steam-Engines.—The value of the steam-engines exported from the United Kingdom in the ten months ending October 31st, last year, was computed at £1,429,499, as compared with £1,470,171 in the corresponding period of 1868, and £1,717,270 in the corresponding period of 1867. The value of the steam-engines exported to Russia was largely increased last year, having risen to £294,284, as compared with £149,618 in the corresponding period of 1868, and £65,189 in the corresponding period of 1867. While the demand for English steam-engines largely increased last year in Russia, it has declined in India, in consequence of the slackening which has taken place in the work of Indian railway construction. Thus, in the ten months ending October 31st, we only sent to India steam-engines to the value of £241,496 as compared with £472,601 in the corresponding period of 1869, and £811,961 in the corresponding period of 1867. There was rather an improved demand last year for English steam-engines in Egypt and Australia, but a falling off occurred as regards France, Spain, and Brazil.

MILITARY ENGINEERING.

The new field gun for India is to be a muzzle-loading 9-pounder bronze rifled gun, weighing 8 cwt., and Col. Maxwell, Royal Artillery, who read a paper on the subject on the 14th ult, stated that the 9th Brigade is about to be armed with the new weapon. The gun will be fitted with Sir J. Whitworth's elevating screw, and, with the carriage and the usual spare gear, &c., will weigh about 32 cwt.

STEAM SHIPPING.

It was announced from Marseilles on the 13th ult. that the *Europe* steamer, 3,500 tons, 400-horse power, had arrived there from Bombay on 12th ult, with 37 passengers. She left Marseilles on the 1st of January, and has, therefore, accomplished the two passages, *viâ* the Suez Canal, including discharging and reloading, in 70 days.

Quick Passage to Bombay *via* the Suez Canal.—The *Bywell Castle*, s., belonging to Messrs. Palmer, Hall, and Co., arrived at Bombay on the 16th ult., after a passage of thirty-five days from the Thames, including three days occupied in passing through the canal.

Suez Canal.—Direct steam communication between Holland and her Eastern dependencies (Java, Sumatra, Sunda Islands, &c.) *viâ* the Suez Canal is being organized at Amsterdam, under the honorary presidency of Prince Henry of the Netherlands, brother to the King of Holland.

SHIPBUILDING.

Steam to Australia.—Messrs. Robert Napier & Sons have now in course of construction for Messrs. Devitt & Moore, of London, a magnificent screw-steamship of about 3,000 tons register, to be fitted with a pair of compound expansion engines, capable of maintaining an actual working power of 2,000 horse. The steamer is intended for Messrs. Devitt & Moore's already well-known London and Australian passenger line, and will be commanded by Captain George MacDonald. In addition to her great steam power, she will be so rigged that in the event of an accident to the machinery she will, in point of speed and safety be equal to any first-class sailing clipper afloat. We trust that the large amount of surface thus exposed to an adverse wind, when under steam alone will not be found so disadvantageous as in auxiliary ocean steamships.

Shipbuilding on the Humber.—The iron shipbuilding trade at Hull is in a more active condition than for some years, several steamers of very large tonnage being in course of construction, while others are fitting out in the dock. One of the finest steamers ever built at Hull has lately been completed,—viz., the *Orlando*, built by Messrs. C. and W. Earle for Messrs. Wilson, Sons, and Company. Messrs. Wilson have a contract with the Swedish Government for the conveyance of the Swedish mails, and the *Orlando* is intended for that service, and for the accommodation of the ever-increasing number of tourists to Sweden. The *Orlando* was put upon her trial trip on the 18th ult., and although she was too light to be in good trim she steamed about 12½ knots an hour. She is 260ft. long, 34ft. wide, and is 1,400 tons gross. She is fitted with compound engines 38in. and 76in. in diameter, 36in. stroke, and combining all the latest improvements, surface condensation, expansion valves, and and everything to insure economy of fuel and speed. Her engines are of 250-horse power, and indicated on trial 850-horse power; pressure, 60lb.; vacuum, 28; revolutions, 59. The passenger accommodation on board is as follows:—Saloon, 50; second cabin, 32; steerage, or emigrant accommodation, 800. The saloon is amidships, the second cabin aft, and the accommodation for emigrants on the main and lower decks, both of which are lofty and well ventilated. This excellent provision for passengers will make the *Orlando* one of the most suitable vessels afloat for the transport of troops should occasion arise for her employment in this service.

LAUNCHES

On the 2nd ult., there was launched from the shipbuilding yard of Mr. John Elder, Fairfield, Govan, an iron screw-steamship of 1,063 tons, of the following dimensions:—Length, 249ft.; breadth, 30ft.; depth of hold, 16ft. 6in.;—having passenger accommodation for 70 first-class and 50 second-class passengers. As she left the ways, she was gracefully christened the *Ban-Righ* by Mrs Ligertwood. The *Ban-Righ* is being fitted with the builder's patent compound engines of 275 horse-power nominal, and is guaranteed to attain a speed of 13 knots per hour. She is being built to the order of the Aberdeen Steam Navigation Company, of Aberdeen, and is intended for their passenger trade between Aberdeen and London.

Launch of the "Abyssinia."—Messrs Thomson lately launched from their building yard at Govan the steamship *Abyssinia*, of 3,500 tons, 650 horse-power. This vessel, the first of four ships of similar dimensions building at present for the Atlantic service of the Cunard Company, has been constructed with the greatest care, and as she is in every way one of the finest specimens of naval architecture afloat, will fully maintain the renown of the company. The ceremony of naming the vessel was gracefully performed by Miss Thomson, daughter of the late Mr. George Thomson, the well-known and much-respected engineer.

Ship Launch.—There was lately launched from the shipbuilding yard of Messrs. M'Culloch, Patterson and Co., Port-Glasgow, an iron barque of 1,100 tons burthen, for Messrs. D. and J. Sproat, shipowners Kirkcudbright. The ceremony of naming the ship *Loch Dee* was gracefully performed by Mrs Sproat, the wife of Provost Sproat, one of the owners. The company thereafter adjourned to the draughting rooms of the builders, where, after the usual loyal toasts were disposed of, "Success to the *Loch Dee* and the enterprising Owners" was proposed by Mr. Patterson, and responded to by Provost Sproat on behalf of the owners. We may mention that this ship takes the berth for Valparaiso under the command of Captain Millar, a gentleman of great experience in the West Coast trade, being under charter to Messrs. Cree, Renison and Co.

Launch at Walker.—On the 19th ult., Messrs. Wigham, Richardson, and Co., of Newcastle, launched from their yard, at Walker, a screw steamer of 2,000 tons and 200 horse power, built to the order and according to the designs and arrangements of Capt. R. B. Durham, for the India and China trades. Her dimensions are 280 by 36 by 26, and her engines, by Messrs. Thompson, Boyd, and Co., are on the compound principle, with surface condensers and all approved modern appliances for saving fuel and giving increased efficiency and ease in working. She was christened the *Vixen* by Miss Mable Croft, niece to Mr. Richardson. It is intended for her to sail from London, on the 14th of May, with a cargo of fine goods and 25 first-class passengers for Madras and Calcutta, and from the latter port to China. The same builders launched a small screw steamer called the *Spitsbergen*, intended for opening a new trade in the White Sea.

TRIAL TRIPS.

The *Favourite*, 10 guns, screw corvette, 2,094 tons, 400-horse power (nominal) of engines, wood built, hull plated with 4½in. armour over the amidships battery and the water-line, was on 15th ult., taken out of Portsmouth harbour, and made a satisfactory preliminary trial of her machinery, preparatory to receiving her armament and being completed for commission again for foreign service. Her working anchor, on the starboard side, is one of Martin's patent self-canting, such as has been fitted to the *Pallas* and other ironclads of the Navy, and a special trial was made of its capabilities after the machinery of the ship had gone through its official trial at Spithead. The anchor, which weighs 57cwt., including the stock, was first let go at Spithead, in 12 fathoms of water, with only 25 fathoms of cable out from the hawse pipe of the ship, in a muddy bottom mixed with fine sand. This brought the ship up effectually, notwithstanding that a heavy lop of a sea was running through the roadstead, which caused the *Favourite* to plunge somewhat heavily. The engines of the ship were then turned astern at about 8-knot speed, to test the holding powers of the anchor, but the latter remained immovable. On heaving the anchor up, it broke out of the ground easily, and came up to the bows of the ship clean. The *Favourite* then shifting her position, the anchor was again let go in about the same depth of water and the same short length of cable, with a muddy bottom, and the results were quite as satisfactory as in the previous trial, the anchor snubbing the ship at once on her short length of cable, and also remaining fast bound to her anchorage with the engines going at eight knots speed astern. Capt. Moriarty, C.B., Master-Attendant of Portsmouth dockyard, made the trials under Admiralty instructions. Mr. Martin, the patentee of the anchor, was also on board. The *Favourite* is one of the earliest vessels converted by the present Chief Constructor of the Navy from the frame of a designed unarmoured wooden corvette to a wood-built ship carrying armour-plating over her central battery and water line. She was during her last commission a very useful ship under both steam and sail, and at the present time, under the new conditions imposed by the great advances made within the last three years in ships, guns, and armour, she would be better without her armour-plating than with it. She is 225ft. in length and 56ft. 9in.; in breadth. Her cost is given by Mr. Reed, in his work on *Our Ironclad Ships*.—Hull, £122,423; engines and fittings, £24,016; masts, sails, stores, &c., £10,206, making in all £156,648. Adding 12½ per cent. as dockyard charges, the total is £173,146. The Accountant-General of the Navy however, says 42 per cent., instead of the moderate 12½ allowed by Mr. Reed.

The new double-screw iron armour plated ship *Invincible*, 14, which, with her engines, was built by Messrs. Napier and Son, of Glasgow, ran six times under full boiler, power over the measured mile outside Plymouth Breakwater, on the 23rd ult., at a mean speed of 13·511 knots, and four times under half boiler power, at a mean of 10·925 knots.

RAILWAYS.

The junction of the line of the East Indian Railway Company with that of the Great Indian Peninsula Company at Jubbulpore has been effected by the completion of the latter to that point, and was opened on the 7th ult, by the Duke of Edinburgh and the Governor-General of India.

TELEGRAPHIC ENGINEERING.

The Britisн-Indian Telegraph Expedition.—The following congratulatory telegrams have been forwarded, upon the successful completion of this enterprise, from John Pender, chairman, Bristish-Indian Submarine Telegraph:—"To Seymour Blane, Calcutta. The Submarine Telegraph between England and India is now complete. Englishmen have shown by carrying out this great work their deep interest in the progress of India. I hope the Government and people of India will fully appreciate the great benefits thus conferred."—"To Hon. Alexander Campbell. Thanks for the very warm interest you have always, with myself, taken in connecting India with England by submarine cable. I congratulate you on the completion of this great work, so important to the imperial and commercial interests of both countries.',—"To Captain Halpin. On behalf of the board I beg to thank you and all engaged with you in carrying out the important work of connecting England and India, which you have so successfully accomplished."—Gibbs (Suez) to John Pender "Cable completed throughout last night (23rd ult.) Signals excellent.

APPLIED CHEMISTRY.

Action of Ozone upon Nitroglycerine, Dynamite, and other Explosive Substances.—According to J. Jonglet's experiments, nitroglycerine, dynamite, iodide of nitrogen, chloride of nitrogen, and some other similar compounds explode the very moment they are brought into contact with ozone; so that, for instance, a drop of nitroglycerine, introduced into a vessel containing ozone, causes an intantaneous explosion. Picrate of potossa gunpowder and ordinary gunpowder are slowly decomposed by ozone, a decomposition which, as regards the last-named substance, takes several weeks before it is perceptible.

Preparation of Tungsten Blue.—By Tessie de Motay.—Dissolve, in a sufficient quantity of water, and successively, 10 parts of tungstate of soda, 8 of tin-salt (protochloride of tin), 5 of ferrocyanide of potassium, and 1 of perchloride of iron. When all these substances are dissolved, the mixture is thoroughly stirred up, and the sediment which is formed is separated by filtration. As soon as the liquid has run off, the moist pasty matter is spread out in thin layers upon suitable glass plates, or shallow dishes, and for several days exposed to the action of strong daylight and sunshine. This slowly causes the formation of a beautifully blue pigment; and this action may be accelerated by washing the material, so as to remove the matters soluble in water which it yet contains. The blue material has a great similarity to Prussian blue, but differs from it by not being bleached by sunlight; akin to Prussian blue, it resists the action of acids, but not of alkalies. The tungsten blue can be heated to about 180° without decomposition. Its per centage of composition, in 100 parts, is—Water, 7·85; tin, 31·69; iron, 5·13; cyanogen, 19·41; blue oxide of tungsten, 35·60; total, 99·68. This blue is not affected by artificial light at all, and is sold at the same price as the very best quality of Prussian blue.

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	From s.	From d.	To £	To s.	To d.
COPPER.						
Best selected, per ton	73	0	0	,,	,,	,,
Tough cake and tile do.	69	0	0	71	0	0
Sheathing and sheets do.	76	0	0	,,	,,	,,
Bolts do.	77	0	0	78	,,	,,
Bottoms do.	79	0	0	,,	,,	,,
Old (exchange) do.	63	0	0	,,	,,	,,
Burra Burra do.	72	10	0	,,	,,	,,
Wire, per lb.	0	0	10	,,	,,	,,
Tubes do.	0	0	11	,,	,,	,,
BRASS.						
Sheets, per lb.	0	0	8½	0	0	9
Wire do.	0	0	7½	,,	,,	,,
Tubes do.	0	0	10½	,,	,,	11½
Yellow metal sheath do.	0	0	6½	0	0	6⅞
Sheets do.	0	0	6¼	,,	,,	6⅜
SPELTER.						
Foreign on the spot, per ton	19	15	0	20	0	0
Do. to arrive	19	10	0	19	15	0
ZINC.						
In sheets, per ton	24	0	0	,,	,,	,,
TIN.						
English blocks, per ton	124	0	0	,,	,,	,,
Do. bars (in barrels) do.	125	0	0	,,	,,	,,
Do. refined do.	127	0	0	,,	,,	,,
Banca do.	122	0	0	123	0	0
Straits do.	119	0	0	120	0	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	6	0	1	8	0
IX. do. 1st quality do.	1	12	0	1	13	6
IC. do. 2nd quality do.	1	5	6	1	6	6
IX. do. 2nd quality do.	1	11	6	1	12	6
IC. Coke do.	1	3	0	1	3	6
IX. do. do	1	9	0	1	9	6
Canada plates, per ton	13	10	0	14	0	0
Do. at works do.	13	0	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	2	6	7	5	0
Do. to arrive do.	7	5	0	,,	,,	,,
Nail rods do.	7	5	0	7	10	0
Stafford in London do.	8	5	0	9	0	0
Bars do. do.	8	0	0	9	0	0
Hoops do. do.	8	17	6	10	15	0
Sheets, single, do.	9	15	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	0
Bars, common, do.	6	15	0	,,	,,	,,
Do. mrch. Tyne or Tees do.	6	10	0	,,	,,	,,
Do. railway, in Wales, do.	6	12	6	7	0	0
Do. Swedish in London do.	10	0	0	10	2	6
To arrive do.	10	0	0	,,	,,	,,
Pig No. 1 in Clyde do.	2	18	6	3	5	6
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. No. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	10	0	5	15	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pig in London do.	6	0	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	13	10	0	13	15	0
Do. (hammered) do.	14	15	0	,,	,,	,,
Do. in faggots do.	15	15	0	16	0	0
English spring do.	17	0	0	23	0	0
Quicksilver, per bottle	6	17	0	,,	,,	,,
LEAD.						
English pig, common, per ton	19	10	0	19	15	0
Ditto. L.B. do.	19	0	0	,,	,,	,,
Do. W.B. do.	19	10	0	,,	,,	
Do. sheet, do.	19	5	0	19	7	6
Do. red lead do.	20	0	0	20	10	0
Do. white do.	27	0	0	30	0	0
Do. patent shot do.	22	0	0	,,	,,	,,
Spanish do.	18	5	0	,,	,,	,,

*At the works 1s to 1s. 0d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addrsing a letter, prepaid, to the Editor of "The Artizan."

Dated February 22nd, 1870.

512 W. B. Adams—Railways, &c.
513 R. Gardner—Producing photographic effects by lithographic printing
514 H. Ferguson—Cooking ranges
515 W. R. Lake—Producing an improved black pigment
516 F. J. Hamel—Compressing fuel
517 A. W. Bain—Producing end and cover papers for books
518 W. Adams—Dressing stone
519 F. Fitzgerald—Securing cattle
520 A. M. Clark—Combination tools

Dated February 23rd, 1870.

521 G. H. Ellis—Washing, &c.
522 W. Crombleholme—Connecting railway carriages
523 W. E. Newton—Springs
524 H. A. Bonneville—Manufacture of the legs of boots
525 G. Leech—Stocks
526 T. Grimshaw—Weft forks
527 J. Farmer—Drying fabrics, &c.
528 T. Andrew—Improvements in hand punching machines
529 E. Punshon—Raising weights
530 G. Rydill—Extracting and purifying mill waste
531 C. H. Aston—Preventing the radiation of heat
532 T. H. Leaker—Buttons, &c.
533 A. M. Clark—Horseshoe nails
534 C. Davy—Improvements applicable to picks and other tools
535 A. M. Clark—Filing papers
536 J. H. Johnson—Straining pulp
537 W. R. Lake—Alarm apparatus

Dated February 24th, 1870.

538 R. Maynard—Chaff engines
539 J. J. Aston—Propelling vessels
540 E. P. H. Vaughan—Splitting rocks
541 H. A. Bonneville—Steam engines
542 G. Asker—Shirt fronts
543 A. Dickson and T. Low—Manufacture of pressed leather
544 E. T. Hughes—Nails
545 J. E. Core—Kilns or ovens for burning or baking bricks
546 E. Duce and S. Noble—Reeving slivers of wool, &c.
547 R. Cook—Frames of umbrellas
548 W. Brown and C. N. May—Heaters for steam generators
549 W. E. Newton—Boilers, &c.
550 A. V. Newton—Needles
551 W. E. Newton—Windmills
552 G. A. Haddart—Permanent way
553 H. Bessemer—Steam vessels
554 J. B. Elkington and C. E. Ryder—Copper tubes, &c.

Dated February 25th, 1870.

555 J. Bullough—Warping machines
556 W. B. Leachman—Raising water
557 W. R. Lake—Producing and utilising a fall of water
558 H. A. Bonneville—Axles, &c.
559 T. Blackwood—Marine engines
560 G. H. Harrison—Lifting potatoes
561 S. Moorhouse—Furnaces
562 E. Tumlinson—Type design and colour printing on paper
563 A. V. Newton—Screws
564 J. H. Johnson—Sewing machines
565 J. J. Holden—Charging gas retorts
566 P. K. M. Skinner—Propelling vessels
567 C. and S. H. Dening—Brushes
568 P. J. Livesey—Hair cloth
569 J. Saxby and J. S. Farmar—Working railway points

Dated February 26th, 1870.

570 A. Wingard—Paddle wheel
571 S. Firth and F. Hurd—Excavating coal, &c.
572 J. McElroy and C. Kearsley—Communicating between the guards, drivers, and passengers of railway trains
573 R. W. Thomson—Omnibuses
574 A. H. Martin—Looms
575 T. Bell and F. Roper—Feeding threshing machines
576 R. J. Westley—Billiard tables
577 J. R. Maun—Waterclosets
578 A. Godillot—Military tent
579 T. Coles—Running wheels, &c.
580 A. Bobrownicki, A. D. M. Mesnard, and Vicomte de Chousy—Converting human excrement into fuel
581 D. Cameron—Pens
582 W. Clark—Governors for steam engines
583 A. M. Clark—Wheels

Dated February 28th, 1870.

584 A. Ripley—Rotary engine
585 J. Wakefield and J. Kendall—Indicators for steam boilers
586 R. T. Sutton—Checking the receipts by money takers, &c.
587 C. Duff—Treatment of certain fibrous substances
588 T. Cattell—Treating fibrous vegetable substances
589 R. Richardson—Harbours, &c.
590 H. W. Dee—Caps for bottles
591 T. Thomas—Preventing accidents in the pits of mines
592 A. V. Newton—Sewing machines
593 T. Clayton and J. Taylor—Gas from mineral or other oils
594 C. W. Siemens—Treating iron ores

Dated March 1st, 1870.

595 J. Parkinson—Apparatus for giving an alarm in steam boilers, &c.
596 M. Wilkin, J. Clark, and A. Scott—Subdividing particles of water
597 R. S. Norris—Getting coal
598 T. Rowatt—Testing oils
599 L. Sterne—Wheel tyres
600 B. G. George—Pictorial devices
601 R. W. Thomson—Applying steam power in cultivating land
602 W. and R. Mushet—Moulding metals
603 W. L. Wise—Firearms
604 H. Hayward—Yarns, &c.
605 A. M. Clark—Wheels
606 A. M. Clark—Artificial flowers

Dated March 2nd, 1870.

607 D. Forbes and A. P. Price—Treatment of sewage, &c.
608 T. Brown—Feeding steam generators with water
609 F. L. H. W. Bunger—Arrangement of steam traps
610 G. C. Thompson—Cranes
611 W. S. Lowe—Tape dressing machines
612 H. Crowther—Turning over the leaves of music books
613 J. Harman—Railway carriages
614 B. Johnson and E. B. Ellington—Hydraulic cranes
615 C. E. de Loriere—Rotary motion
616 T. S. Davis—Alloy
617 J. Neale and J. B. Fenby—Attaching lamps to carriages
618 J. H. Johnson—Enamels
619 W. Darley—Illuminators
620 G. E. Donisthorpe—Cutting coal

Dated March 3rd, 1870.

621 G. H. Ellis—Ladders
622 J. Broadley—Couplings
623 R. B. Boyman—Propelling vessels
624 J. Linfoot—Fixing bristles, &c.
625 J. Bowrah—Communication between passengers, &c.
626 J. Armitage—Case hardening
627 S. E. Phillips—Electric cables
628 J. Wheeler—Fastenings for gloves
629 J. S. Johnstone—Motive power engine
630 J. C. Morrell—Treatment of refuse for sanitary purposes
631 A. V. Newton—Fluid meters
632 J. Clegg—Looms
633 F. Walton—Construction of houses and other buildings
634 W. H. Bailey—Boiler fittings
635 J. T. Griffin—Oiling the bearings of revolving shafts
636 W. R. Lake—Permanent way

Dated March 4th, 1870.

637 R. Young—Treating grain
638 H. Siebe, W. A. Gorman, and T. Forster—Diving dresses
639 J. Raphael—Sunshades
640 W. E. Gedge—Syringe
641 W. Tyrer—Propellers for ships or other navigable vessels
642 T. Atkins—Generating gases for extinguishing fires, &c.
643 E. J. C. Welch—Using the lime light for theatrical representations
644 J. A. Matthews—Moulding bricks
645 J. A. Hogg—Safety lamps
646 S. Cohen—Waterproof garments
647 R. A. E. Scott—Mounting, working, pointing guns, &c.
648 A. F. W. Louis—Improvements applicable to chairs, &c.

Dated March 5th, 1870.

649 J. Allman—Dressing grain
650 J. Pickering—Castors
651 J. Strang—Dressing or finishing and printing textile materials
652 E. Robinson, C. F. Robinson, and J. E. H. Andrew—Twisting tobacco, &c.
653 H. Sykes—Spinning or twisting worsted substances
654 E. O. Taylor and J. Field—Moulding flanged pipes
655 G. Elliot—Ventilating rooms
656 S. H. Stott—Treatment or preparation of yarns for weaving
657 E. Bray, J. C. Hargreaves, and F. H. Stubbs—Burning smoke
658 E. Stevens—Kitchener
659 F. C. Hills—Sea going vessels
660 S. Meredith—Furnaces
661 J. Hipkiss and S. Whitehouse—Sad and other smoothing irons
662 J. E. Ransome and J. R. Jefferies—Double furrow ploughs
663 F. T. Ferguson—Device for holding letters and other documents
664 A. M. Clark—Power for the propulsion of vehicles

Dated March 7th, 1870.

665 E. Wood—Potters' glazes
666 G. G. Lowe—Cisterns
667 G. Holcroft and R. M. Roberts—Treating auriferous ores
668 J. Hargreaves and T. Robinson—Manufacture of chlorine
669 W. A. Fell—Mowing machines
670 P. J. Robine—Boilers, &c.
671 J. Brooks—Watch protector
672 H. Herbert—Boxes for containing furs
673 W. E. Newton—Injecting liquids to a state of spray
674 F. Wilkins—Ships
675 W. Law—Pulp for making paper or papier mache
676 W. R. Lake—Sweeping carpets

Dated March 8th, 1870.

677 C. J. Fox and R. Larchin—Improvements in mowing machines
678 J. Pilgrome—Improvements in the construction of rails
679 G. W. Wigner—Drying machines
680 S. Brooks, G. Harrison, and J. Wardle—Spinning, &c.
681 A. Villepigue—Boring
682 R. A. Wiffen—Tapping cock for drawing liquids from casks
683 J. Polson—Treating grain
684 C. H. Williams—Means for curing skin diseases in animals
685 W. Cowan, A. Donaldson, and J. Sandilands—Gas meters
686 J. L. Norton—Looms
687 J. Lang—Firearms
688 W. R. Lake—Method of executing submarine constructions
689 G. Preston and J. Prestige—Preventing waste of water
690 C. Wyndham—Bicycles
691 W. E. Newton—Generating steam or elastic vapours

Dated March 9th, 1870.

692 J. Hopkinson—Arrangement of furnace and boiler
693 H. Potter—Bleaching
694 J. Duffey—Receptacles to be used as a protection from fire
695 T. S. Truss—Boilers, &c.
696 J. Nailson—Manufacture of hollow cast iron cooking utensils
697 G. Fowler—Smelting iron ore
698 W. O. Wilson—Millstone picks
699 M. Frow—Gathering and binding of cut crops into sheaves
700 W. R. Lake—Surface printing
701 W. R. Lake—Threshing machines and driving mechanism

Dated March 10th, 1870.

702 O. Ormrod and R. Hall—Finishing threads of cotton, &c.
703 T. Newton—Firearms
704 R. Blakeborough and S. Sanderson—Steam boiler furnaces
705 H. S. Gibson—Hats
706 C. A. Winder—Drawing and forcing water and other liquids
707 J. W. Grover—Rolling stock
708 J. Brady—Skirts
709 J. A. Tatro—Converting petroleum into a safe burning oil
710 J. H. Johnson—Wheel tyres, hoops, and such like articles
711 J. Jeavons—Armour plates
712 T. W. Walker—Enamelling stone
713 J. J. Lundy—Decolorisation and purification of foul waters
714 W. R. Lake—Extinguishing fire
715 S. Chatwood and J. Sturgeon—Direct power hammers
716 M. Henry—Tanning
717 J. Wallace—Distilling

Dated March 11th, 1870.

718 J. A. Hopkinson and J. Hopkinson, jun.—Steam engine indicators
719 F. Brusch—Automatic apparatus for dampers of furnaces
720 G. Paley—Putting twist in sliver, &c.
721 J. Wright—Watering gardens
722 J. Moysey and C. Thorne—Improvements in hackling machinery
723 G., E., and A. A. Atkin—Reducing bones to small particles
724 J. H. Johnson—Combing flax
725 H. A. Bonneville—Improvements in machines for setting types
726 C. Jackson—Vulcanisers
727 J. Siddons and D. B. Meese—Improvements in clocks
728 P. C. Thamseu—Leather
729 M. Heury—Improvements in the construction of piers
730 L. Silberberg—Cigars
731 J. Connell—Improved apparatus for the manufacture of sugar

Dated March 12th, 1870.

732 W. Pennington—Plaiting linen and other fabrics
733 A. Kay—Tramways
734 J. Brown—Carding engines for carding hemp, flax, &c.
735 J. Donnachie—Stoves
736 J. Poltou—Application of machinery for treating grain
737 G. Tyzack—Windlasses
738 W. Nicholson and D. Hopkins—Clog for roughing horses
739 A. Du Bled, P. Chenaillier, and J. Aufpret—Cartridge holder

Dated March 14th, 1870.

740 J. Morris—Jacquard apparatus
741 W. Paye—Furnaces
742 G. Townsend—Lawn edge clippers
743 J. Glover—Regulating the flow of air into surfaces
744 W. R. Lake—Indicating deficiency of water in boilers
745 S. D. McKellen—Watches
746 J. J., J. J. F., and W. A. Stevens—Working railway signals
747 W. Arkell—Raising heavy bodies
748 T. Routledge—Paper

Dated March 15th, 1870.

749 W. Husband—Hammers
750 J. Felber—Paper
751 R. Winstanley and W. Barker—Excavating coal
752 W. R. Pape—Firearms
753 H. Manton and J. H. Mole—Swivels
754 G. Brown—Velocipedes
755 W. H. Samuel—Friction lights
756 R. S. Prowse—Hand trucks
757 F. Pattison—Manufacture of blackening for foundry purposes
758 J. C. McLagan—Sewing machines
759 J. S. Atkin, I. Deely, and F. Newbery—Furnaces
760 C. Stockbridge—Saddles for horses
761 J. C. Ramsden—Looms
762 J. H. Johnson—Regulating the speed of motive power engines
763 P. C. N. de Ferrari—Hats
764 D. and J. Dugdale—Sizing machines
765 G. Jaite—Telegraphical apparatus, termed Jaite
766 G. H. Brockbank—Pianoforte actions
767 P. W. Spencer—Limekilns
768 J. Beckett and R. Levers—Buckles
769 W. F. Newton—Maltkilns
770 W. E. Newton—Gun carriages
771 R. Lakin, W. H. Rhodes, J. Wain, and W. Greasley—Mules for spinning

Dated March 16th, 1870.

772 R. Tongue—Looms
773 W. C. Mitchell—Books
774 W. Moagan—Preservation of life from fire
775 G. Holdsworth—Drawings
776 W. and W. Rainforth—Dressing and separating grain
777 P. Murray—Moving heavy bodies
778 H. W. Hammond—Firearms
779 J. C. Mewburn—Raising fluids
780 J. T. Walker—Horseshoe
781 W. R. Lake—Forming trenches
782 J. Holman—Waggons
783 J. Watkins—Dies
784 J. H. Johnson—Construction of roads
785 F. Virtue—Registering the pressure in hydraulic presses
786 J. Moulton—Elastic rolls for wringing clothes
787 D. Spill—Xyloidine
788 G. Buck—Sewing machines

Dated March 17th, 1870.

789 T. Williams—Sewing machines
790 J. Pinchbeck—Boilers
791 G. de Lavigne—Retaining caloric
792 W. E. Gedge—Damping woven fabrics
793 F. A. Barrow—Distilling
794 J. Walker—Bottles
795 E. R. Southby—Distilling
796 M. T. Hughes—Presses
797 A. M. Clark—Stereotype moulds
798 J. and W. N. Davis—Ploughs
799 C. H. Rost—Washable papers
800 T. J. Smith—Holding postage stamps

Dated March 18th, 1870.

801 S. Perkins—Boilers
802 C. Janicot—Producing photographic pictures on fabrics
803 R. Girdwood—Cutting stone
804 W. West—Generating steam
805 C. Young—Sawing wood
806 J. H. Johnson—Crimping machines
807 G. White—Propellers
808 H. E. Newton—Limekilns
809 J. M. Napier—Pouring metals
810 W. Fairbairn—Steam boilers
811 W. Woofe—Guiding ploughs, and regulating their depth of working
812 W. Friar—Fire escapes
813 W. Austin—Boxes
814 W. Guest—Ropes

Dated March 19th, 1870.

815 A. M. Strathern—Cutting minerals
816 T. Keely—Looped fabrics
817 S. Norris—Wood paving
818 J. Hockey—Ventilating lights
819 G. W. Fox—Rendering cod liver and other oils more palatable
820 W. A. Lytile—Wheels
821 W. R. Lake—Sewing boots
822 B. Wade—Railway brakes
823 J. S. and B. Stocks and S. Hutchinson—Shaving hides
824 G. Weedon—Cleaning knives
825 G. Kent—Combined carving fork and knife cleaner
826 C. J. H. Warden—Fastening carriage doors
827 R. F. Fairlie—Wheels

Dated March 21st, 1870.

828 J. Stirling—Railway brakes
829 J. Ferris—Lubricating slide valves
830 G. Barker and J. McFarlane—Copying letters
831 P. M. Walker—Shoeing horses
832 J. Millar—Obtaining motive power
833 S. Brooke—Doffers of carding engines
834 A. V. Newton—Barrels
835 J. Ascough—Candles
836 G. Skey—Gas purifiers
837 W. R. Lake—Wheels
838 A. Barlow—Weaving
839 W. R. Lake—Micrometic steelyard

Fig 1. Longitudinal Section through Revolving Cylinder and Evaporating Pan

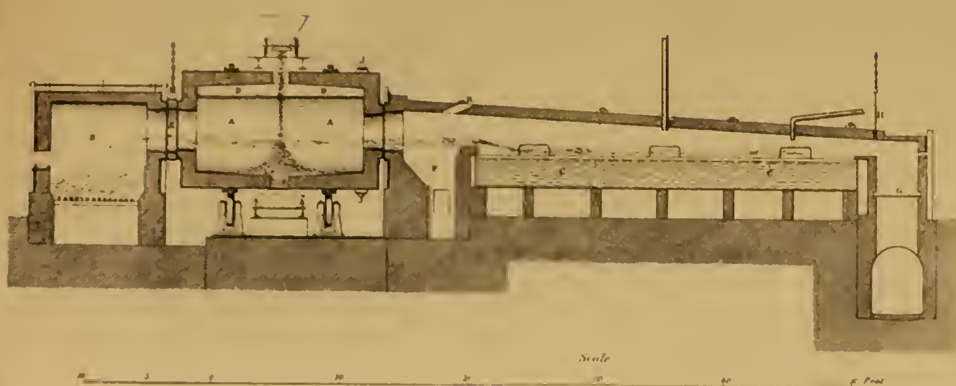
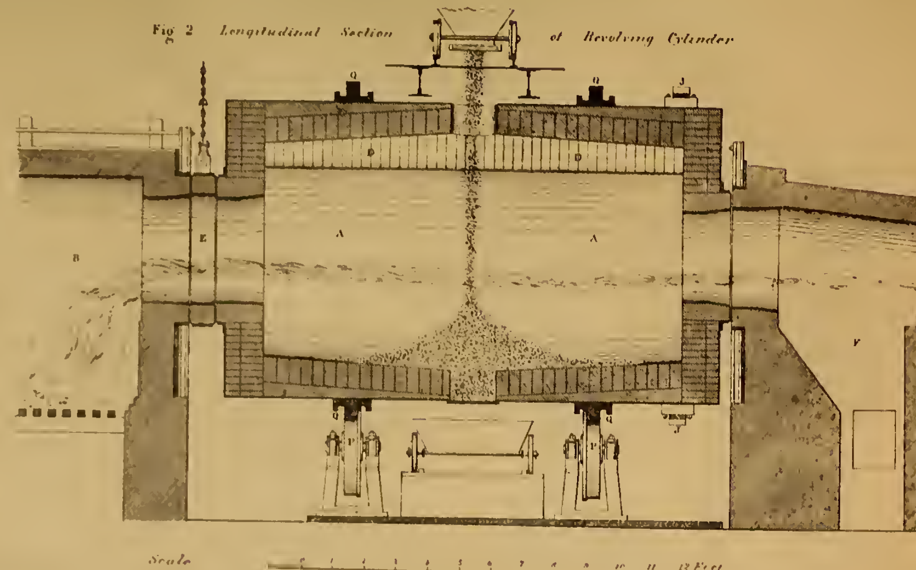


Fig 2. Longitudinal Section of Revolving Cylinder



REVOLVING FURNACE FOR CHEMICAL WORKS.

BY Mr R. CLAPHAM & Mr C. ALLHUSEN,

NEWCASTLE

Fig 3. Transverse Section at Centre of Revolving Cylinder

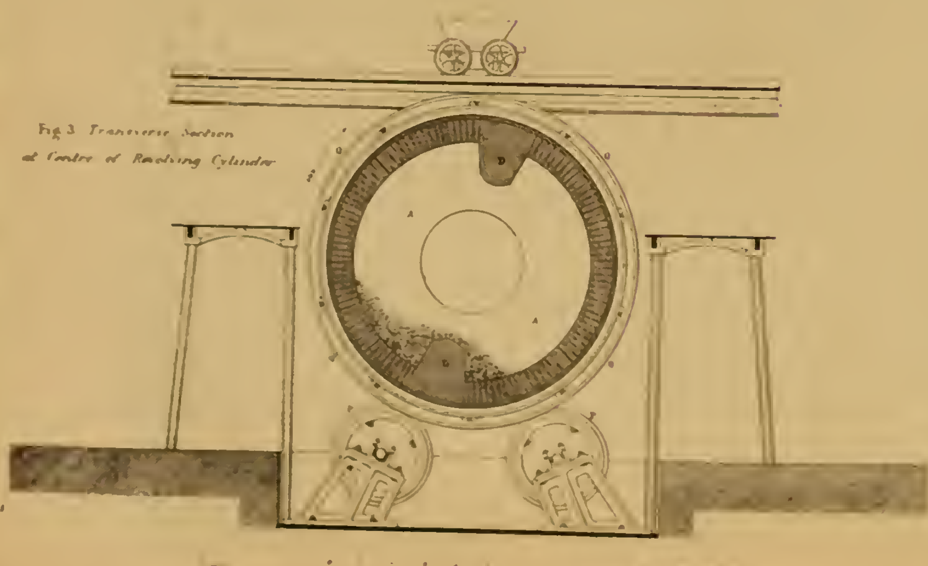
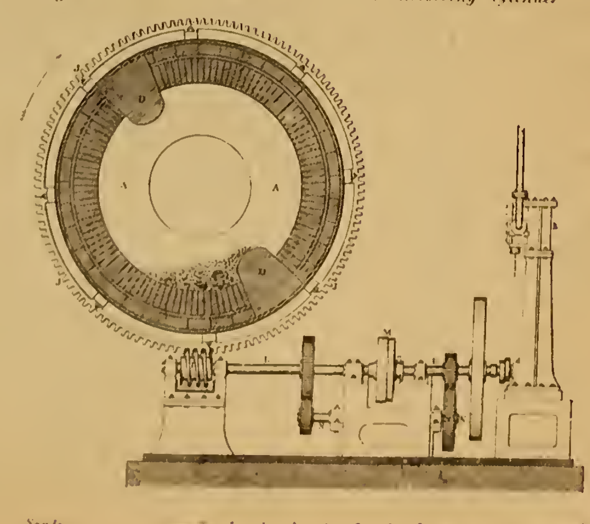


Fig. 4. Transverse Section at End of Revolving Cylinder



W. Smith C.E. direx

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REVOLVING FURNACE FOR CHEMICAL WORKS.

By Mr. R. Calvert Clapham and Mr. Henry C. Allhusen, of Newcastle.*

(*Illustrated by Plate* 360).

The conversion of Sulphate of Soda into Crude or Ball Soda is the third process conducted in alkali works; and its importance will be understood from the statement that in the Tyne district alone, 455,000 tons and £560,000 represent the total annual quantity and value of the sulphate of soda, chalk, and coal, operated upon in reverberatory and revolving ball furnaces. The revolving furnace was introduced in 1853 by Messrs. George Elliott and William Russell, with the object of effecting by machinery that which from 1794 had been accomplished by hand labour; but owing to the numerous practical difficulties encountered, the economy and other advantages expected were not realised, and no extensive application of the revolving furnace would yet have taken place, had it not been for the perseverance of Messrs. Stevenson and Williamson, of the Jarrow Chemical Works, who made improvements on the original plan, and erected five of the fifteen revolving furnaces that are now working in England.

In this description of furnace the charge of material to be acted upon is placed in a revolving cylinder A, shown in the general longitudinal section, Fig. 1, Plate 360, and to a larger scale in the longitudinal and transverse sections, Figs. 2, 3, and 4. This cylinder is constructed of 5-16ths in. boiler-plate lined with firebricks, and is mounted so as to allow the heat from the firing furnace B at one end of the cylinder to pass conveniently through it and over the liquid contained in the evaporating pan C at the other end, Fig. 1. In exterior measurement the cylinder is 15ft. 6in. long and 9ft. diameter; and its interior measurement is 13ft. 3in. length, 7ft. 6in. diameter in the centre, and 6ft. 6in. diameter at either end. In the brick lining are fixed two rows of fireclay blocks D D, Figs. 3 and 4, termed "breakers," which stand 14in. above the lining in the centre and 9in. at the ends; by these breakers the contents of the cylinder are thoroughly mixed and successively exposed to the fire. Between the firing furnace B and the cylinder A a loose collar E is adjusted, Figs. 1 and 2, which consists of a wrought-iron hoop lined with firebricks; and between the cylinder and the evaporating pan C at the other end a space F is left, termed the "smoke-chamber," so that the greater portion of the particles carried forward by the strong draught may be deposited there, instead of in the liquid to be evaporated. In the downcast at the extremity of the pan C a main horizontal damper G is secured by a chain, so that no more than the requisite draught can be obtained; and further control over the draught is given by a vertical damper H placed between the pan and the downcast, and counterbalanced by a weight suspended near the engine.

The mechanical apparatus for rotating the revolving cylinder, as shown in Figs. 2 to 4, Plate 360, rests on a bed-plate 2½in. thick, which is cast in five pieces fastened together by six wrought-iron hoops shrunk on the whole being secured to the stone foundation by twelve 1¼in. bolts. The vertical direct-acting engine K, Fig. 4, with reversing link motion, has an inverted cylinder 9in. diameter and 12in. stroke, working at 6 horse power with 30lbs. pressure. The cylinder A of the furnace makes one revolution per minute when in the quick motion, and one revolution per five minutes when in the slow motion. The quick motion is obtained direct from the crank through the upper line of shafting L L, upon the end of which is a worm I working into a large wormwheel J J fixed round the pan end of the revolving cylinder by means of feet and screw bolts. In some cases this wormwheel has been cast in segments; but on account of their inaccuracy and the difficulty experienced in getting the pitch of the teeth correct at the joints, a single casting is deemed preferable. The slow motion is obtained by disengaging the friction cone M on the upper shaft L, and putting into gear the lower shaft N, so that the spur-wheel and pinion at either end of the lower shaft N work into the pinion and spur-wheel on the upper shaft L.

The revolving cylinder A is carried upon two pairs of cast-iron flanged bearing wheels P P, Figs. 2 and 3, with 4½in. axles supported on diagonal carriages. The bearing surfaces of the cylinder are two cast-iron rings Q Q riveted round its circumference, and each strengthened by two wrought-iron hoops 1½in. square. Each ring is faced with a wrought-iron tyre, secured by countersunk bolts, and in some instances the tyres have been shrunk on in one piece, after boring them out and turning the rings; but the expansion from the pressure and heat sooner or later cause the tyres to roll out and become loose, and consequently to snap the bolts. For this reason it is found advisable to fix the wrought-iron tyre in segments, with diagonal face joints, and to have the countersunk bolts passed through oblong holes in the cast-iron ring, by which means expansion is allowed for and the breaking of the bolts prevented.

The charge for the revolving furnace at the Tyne Chemical Works consists of

Sulphate of Soda	22 cwts.
Chalk	25 „
Coal	12 „

The sulphate of soda falls through a ½in. screen, as delivered into the depot, and thus an adequate quantity of fine material is secured for the cylinder without expense; the chalk is charged into the cylinder in moderate sized blocks, whilst the coal is divided, 3 cwts. being mixed with the sulphate and 9 cwts. with the chalk. On the day-shift, during which the evaporating pan is drawn, five charges are worked, and on the night-shift six, the full work being six days at 12 tons 2 cwts. of sulphate of soda per 24 hours, making 72 tons 12 cwts. per week. The method of proceeding is as follows:—in the first place the 25 cwts. of chalk and 9 cwts. of coal are charged, and the cylinder is made to revolve with the slow motion. After the expiration of 1 hr. 10 mins. the "liming" or conversion of the chalk into lime is generally effected, and its completion is always indicated by a bluish flame round the charging door; the 22 cwts. of sulphate and 3 cwts. of coal are then added, and the vertical damper H, Fig. 1, is lowered for ten minutes, so as to give the smallest possible amount of draught. In about twenty minutes after the damper has been raised again, the fluxing of the sulphate becomes apparent by the escape of a bright yellow flame round the charging door, and the motion of the cylinder is then changed at once from slow to quick. A small door R in the arch over the pan C, Fig. 1, enables the workman to ascertain when the decomposition of the materials is sufficiently advanced, of which he judges by their clear colour and increasing consistency, and also by the light yellow jets of flame that issue from portions of the fluxed mass adhering to the breakers in the cylinder. This stage is usually attained in half an hour, and the contents of the cylinder are then run out, the total

* Paper read before the Institution of Mechanical Engineers.

time expended on the whole operation amounting on the average to 2 hrs. 10 mins.

In comparing the working of the revolving furnace with that of the ordinary hand furnaces, it must be borne in mind that any such comparison is affected by a variety of local circumstances; and the results given in the present paper have principally been deduced from observations made and abstracts taken at the Tyne Chemical Works, where there are twenty-five hand furnaces and two of the revolving furnaces, and all the materials charged are elevated by means of a waggon and lift.

The cost of construction of a revolving furnace may be estimated at about £1,500, exclusive of the charging machinery, and the building containing the furnace would cost about £500 per furnace, making the total cost of the furnace about £2,000. A hand furnace costs about £325, and its containing building about £175, making £500 total. The expenditure involved in crushing and elevating the materials may be considered equal in the two cases; but the revolving furnace requires steam for its engine and liquor pump, and a proportionately stronger draught, thus necessitating a greater outlay on the boiler, flue, and chimney. When in thorough order a revolving furnace can ball 72 tons 12 cwts. of sulphate of soda per week of six days, and a hand furnace 21 tons 12 cwts.; but taking into account stoppages for repairs, the former does not exceed 66 tons per week, whilst the latter accomplishes 21 tons.

The consumption of coal, including firing, heating up, chalk-drying, and raising steam, is less in the revolving furnace than in the hand furnace and with some qualities of coal the difference has been found to be 1·5 cwts. per ton of sulphate balled, the consumption being 10·7 cwts. per ton of sulphate in the revolving furnace against 12·2 cwts. in the reverberatory furnace. The reverberatory furnace requires dry and ground chalk, and half of the chalk used in it is dried in kilns, and is then ground in a mill with the remaining half wheeled direct from the depot; but the revolving furnace can be charged with damp and rough chalk, and the whole of the chalk supplied to it is used without drying or grinding. An advantage is thus afforded to the revolving furnace of 6d. per ton on the sulphate balled, which however has thus far been seriously reduced by the difference in cost of repairs, the account for repairs from September 1867 to June 1869 showing 1s. 3d. per ton of sulphate in the revolving furnace against 10d. in the hand furnace. The rate paid for charging the furnaces is identical; but in working them there is a distinct saving in wages with the revolving furnace of 1s. per ton of sulphate, the present cost of working being 2s. 6d. per ton of sulphate in the hand furnaces and 1s. 6d. in the revolving furnace, inclusive of heating up.

The chemical results are slightly in favour of the revolving furnace, so far as the quantity and strength of the alkali produced are concerned, especially where causticity is required; but in the works where chalk is used instead of limestone, the carbonate of lime carried over by the draught into the evaporating pan is found to render the salt drawn out not so well adapted to the manufacture of crystals of soda as that taken from the hand-furnace drainer.

Although in the majority of alkali works where the revolving furnace has been adopted, the opinion obtains that in addition to general superiority over the reverberatory furnace it also presents an evident advantage during wages disputes, yet there are sufficient grounds for stating that obstacles still exist which must be modified, if not removed, before the old furnace can be entirely superseded by the new one. Improvements in the latter are clearly required for reducing the consumption of coal and the cost of repairs, and for increasing the quantity of sulphate balled and improving the quality of carbonate produced; and in referring in the present paper to the difficulties hitherto experienced, it is hoped that by the attention directed to them they may more speedily be overcome.

A concession for the laying of a cable from Constantinople to Odessa has been granted to a company, which is represented at Constantinople by M. Coumbari, director of the Observatory.

PATENT CASE.

The Ejector Condenser.

The action of Neilson and others *v.* Barclay, in which important questions as to the protection of patents are involved, came on for hearing in the First Division of the Court of Session, Glasgow, on March 23rd, before the Lord Justice General and a jury. The pursuers were Walter Montgomerie Neilson, engineer in Glasgow; James Wood, residing at Troon; and Alexander Morton, engineer, Glasgow; and the defender, Andrew Barclay, founder and engineer, Kilmarnock.

From the statement of facts for the complainers, it appeared that the pursuer, Alexander Morton, obtained letters patent under the Great Seal, dated 18th July, 1867, and sealed 14th January, 1868, for the invention of "Improvements in the lateral action or induction of fluids, and in the apparatus or mechanism employed therefor." By these letters patent, he obtained for the period of fourteen years the exclusive right and privilege of making, using, exercising, and vending that invention within the United Kingdom, and the Channel Islands, and the Isle of Man. In pursuance of the proviso contained in these letters patent, the complainer duly filed in the Great Seal Patent Office a specification particularly describing and ascertaining the nature of the invention, and in what manner the same was to be performed. This specification sets forth that the invention "consists mainly in the construction and arrangement of apparatus by which certain currents of either elastic or liquid fluids or of gases may communicate a simultaneous motion to such other fluids or gases, by their lateral action or induction through a tube or tubes, in area in a certain ratio to the diminishing pressure of the escaping or acting fluids; and the objects and advantages to be gained by my invention are its application to steam engines and injectors, whereby such steam engines and injectors are made more perfect and economical in their working than has heretofore been the case." The different applications of the invention in reference to the injection and ejection of fluids and gases, and the arrangements for the same are then set forth, and the specification concludes by stating the various respects in which the complainer considered his invention novel and original. These were in substance as follows:—1st, The construction and arrangement of apparatus for the induction and exhaustion of fluids generally, as described in the specification. 2nd, The application and use of a jet or jets of steam for the purpose of producing a vacuum or a partial vacuum in the cylinders of high-pressure engines. 3rd, The application and use of a jet or jets of steam to impel water through fluid lateral-action apparatus, for the purpose of producing a vacuum or a partial vacuum. 4th, The application and use of two or more separate and distinct passages for admitting exhaust steam into a fluid lateral action apparatus, for the purpose of producing a vacuum or a partial vacuum. 5th, The application and use of apparatus or injectors for feeding liquids into vessels under pressure, so constructed that the steam or other actuating fluid does not enter or return into the liquid conduit or chamber, but steadily maintains an induced current or partial vacuum therein. 6th, The application and use of a steam-cased induction or fluid lateral-action tube for injectors generally. 7th, The application and use of injectors so constructed that the excess or deficiency of liquid actuates a piston or other regulator of the liquid inlet. 8th, The application and use of injectors so constructed that the excess or deficiency of the water in the overflow chamber regulates the quantity of steam necessary for the proper induction of the water. 9th, The application and use of injectors, so constructed that their actuating steam is shut off and put on by a valve or other regulator, actuated by a feed in the vessels to be supplied with liquid. By assignation, dated 20th November, 1868, Morton made over all right, title, and interest he had in the letters patent, and also the letters patent themselves. The complainers now aver that the respondent has on various occasions since 14th January, 1868, infringed, and is at present infringing, these letters patent, by making, vending, or using improvements in the lateral action or induction of fluids, and in the apparatus or mechanism employed therefor. In particular it is alleged the respondent, in contravention of the letters patent, has fitted up, or is fitting up, three engines, situated respectively at Addiewell Oil Works, near West Calder, at Fauldhouse Pit, and at the respondent's works, Caledonia Foundry, Kilmarnock, condensing apparatus in all essential respects identical with the apparatus described in the specification (now generally known as ejector condensers) as applicable to and for the purpose of producing a vacuum in the exhaust pipes of low pressure or condensing steam engines.

The respondent, in his answers, maintains that the alleged invention, as described in the specification, does not consist of improvements in the lateral action or induction of fluids, and in the apparatus or mechanism employed therefor. The invention, he says, or a material part of it, consists of improvements in steam engines and injectors, and of the special application of the improvements and apparatus of mechanism specified in the title of the letters patent to steam engines, for the purpose of attaining the particular result described in the specification. He maintains, further, that Alex. Morton is not the first and true inventor of the alleged invention; that the invention was not first published in Great Britain by him; and that the alleged invention was published and publicly known and used in

Great Britain prior to the date of the letters patent referred to. Inventions or contrivances similar to or substantially the same with the alleged invention were described and disclosed (1) in letters patent granted to Henry Jacques Giffard, mechanician, of Paris, in 1858; (2) letters patent granted to the respondent, Andrew Barclay, and the complainer, Alex. Morton, dated 7th November, 1863, and sealed 3rd May, 1864; (3) in the letters patent granted to the respondent, dated 6th May, 1864, and sealed 20th October, 1864; and (4) in a provisional specification left by the respondent on 6th March, 1864, at the office of the Commissioners of Patents, with his petition for a patent for improvements in condensing steam engines. The alleged invention was, besides, publicly used in Great Britain prior to the date of the letters patent. An apparatus or condenser constructed in the manner described in the specification, was, in January, 1867, erected and thereafter continued in operation in the respondent's Caledonia Foundry at Kilmarnock. This apparatus was constructed from designs conceived and prepared by the respondent. The complainer, Alexander Morton, was at that time in the service of the respondent, and after the construction of the apparatus he was employed by the respondent to observe and take notes of its action. The descriptions in the specifications libelled on, the respondent maintains, are not such as to enable workmen of ordinary skill to make apparatus or mechanism capable of being beneficially used, or to use and practise the invention so as to produce the effect set forth in the letters patent. The complainer, Alexander Morton, in his specifications does not sufficiently distinguish between what was old and what was new; and he further claims as new inventions and contrivances those which were old and well known at the date of the patent.

The case was opened on March 23rd, for the complainers, by the Solicitor General.

Alexander Morton, one of the complainers, was then called as a witness, and deponed that he had served his apprenticeship in Dundee. In 1860 he went to Kilmarnock, and entered the employment of defender as chief draughtsman. He afterwards assisted generally in the work. In 18-2 or 1863 he communicated an invention to Mr. Barclay. It was an apparatus to lift water, by the direct action of steam from one reservoir to another. That had nothing to do with a condensing apparatus. Shortly afterwards, Mr. Barclay proposed to take out a patent for it, and a patent was taken out accordingly. It was taken out in 1863 in their joint names. That apparatus was successful as a means of raising water. The apparatus could not be used as a blow-through condenser. He was afterwards engaged in trying to discover an improved means for raising water and putting it into steam boilers. He made a model, applied it to the shop boiler, and succeeded. He gave a draft of the rude specification he had prepared to Mr. Barclay, with the view of obtaining a patent. A patent was got for it. Witness had expected that it would be obtained, like the previous one, in their joint names, but he found that Mr. Barclay had got it in his own name. Sharpe, Stewart, and Co., of Manchester, complained of the apparatus as an infringement of their patent, and the use of it was stopped in Mr. Barclay's work. That apparatus had nothing to do with the production of a vacuum, and could not be used as a condenser. Witness left respondent's employment in June, 1867. He took the present patent in July of the same year. He had a long time previously been engaged making experiments. He made these experiments in his own time, and put Mr. Barclay to no expense in regard to them. He had not completed the invention when he left Mr. Barclay's, but he completed it soon afterwards. Mr. Barclay did not communicate the ideas to him on which he worked. Mr. Barclay did not aid him in his discoveries, but rather the reverse. Witness then proceeded to give a minute description of his inventions, and also of the apparatus which he complained of as an infringement of his patent.

Professor Macquorn Rankine, gave evidence showing the different forms, models, &c., between Mr. Morton's and previous patents. He also deponed to having visited Addiewell in July last, and seen a condensing engine in course of erection, the principal action of the condensor, in certain essential points, being the same as Mr. Morton's patent. He had found similar engines at the defender's foundry at Kilmarnock. One of these was more complex than the one at Addiewell, and more correctly proportioned, and in that respect was nearer Morton's patent than the one at Addiewell. He believed he was the first to propose that Mr. Morton's patent should get the name of "ejector-condenser."

Robert Douglas, engineer, Dunnikier Foundry, Kirkcaldy, deponed that he had been connected with practical engineering for thirty years. Mr. Morton was in his employment seventeen years ago as a journeyman engineer and mechanical draughtsman. The specification libelled on of Mr. Morton was sufficiently described to enable an engineer of average ability to get the apparatus produced in his works. He did not think that Giffard's patent of 1858 was an anticipation of the patent of Mr. Morton. The object of the Morton patent was to produce a vacuum in the cylinder, and Giffard's could not produce a vacuum because it had an opening to the external air. It was a patent for an injector, and had not means described of ejecting products of condensation. Stewart and Robertson's patent for improving Giffard's apparatus contained no more indications of Mr. Morton's patent. It differed from it by its having an opening to the air, and also in the narrowness of the throat by which the fluid was expelled from the injector. He had looked at the provisional specification of the patent of 1854 of the defender Barclay. It did not anticipate Morton; and it did not depend on the lateral induction of fluids, as Mr. Morton's did. Morton and Barclay's patent of 1863 did not contain anything to describe or anticipate Morton's patent. He first heard of the words "ejector-condenser" in collocation after Morton's patent. It was a new word among mechanical engineers as far as he knew. He had examined an ejector-condenser at the defender's foundry. There was no doubt it acted on the principle of lateral induction of fluids. He had examined the engines at Addiewell and Fauldhouse, and found them on the same principles as Mr. Morton's patent.

Cross-examined by Mr. Watson: I have not directed so much attention to injectors as to enable me to say whether there is any difference between those of Morton and Giffard, except that certain parts are fixed in Morton's and moveable in Giffard's. I would not take upon me to say whether Giffard's nozzle, with its slides, could be put into the same position as Morton's fixed one. There is lateral action of fluids in both Giffard's and Morton's. I have seen a perfect vacuum formed by Morton's but not by Giffard's.

Wm. Inglis, mechanical engineer, Bolton, gave evidence with reference to the distinctions between the several patents in question. The principle of Morton's proceeded upon giving the same direction to the current of steam and the current of water, and a certain number of openings for each. In Morton and Barclay's patent of 1863 he did not see anything in the arrangement which he would call a condenser. In Mr. Barclay's patent of 1864 the condensers were not ejecting.

Robert Angus, manager at Lugar Ironworks, for Messrs. Wm. Baird, deponed that he had put on two of Mr. Morton's patent "ejector-condensers" to two engines at Lugar and one at Dalry.

John Howie, manager at Messrs. Merry and Cunningham's Ironworks, Dalry, deponed to three of Morton's condensers being fitted on to engines in the possession of firms at Dalry and Kilbirnie, and in Ireland.

Alexander Strathearn, partner of the firm of Strathearn and Murray, Coatbridge, deponed to having made condensers on Morton's patent. One of them was in the North British Ironworks, Coatbridge, and working well.

John Frame, manager of Messrs. Walker's Engineering Works, Glasgow, gave evidence as to making Morton's ejector-condensers.

Wm. Brown, a draughtsman, formerly in the employment of the defender, and now with the complainor, Neilson; and James Goldie, foreman of Vulcan Works, Kilmarnock, were also examined for pursuers.

The Solicitor-General having addressed the jury for the pursuer, Mr. Watson followed for the defender.

The Lord President then summed up, directing the jury to bring in a separate answer to the questions whether the defender had infringed the patent at Addiewell, at Fauldhouse, and at the defender's works in Kilmarnock. The allegation of the pursuer was that at these places the defender used his invention; but, of course, before the jury could answer that question, they must thoroughly understand what the invention was. His Lordship having read the letters patent and specification of the invention, proceeded to say that within the words of the issue was fairly comprehended not the use merely of the very particular apparatus which was specified, but of any other apparatus that was a mere modification or colourable imitation of it. It seemed to his Lordship that the patent secured by Morton was for an apparatus. The patent did not comprehend every mode of producing, or every apparatus producing, the induction and exhaustion of fluids; nor did it include every mode of producing, or every apparatus for producing, a vacuum by means of the application or use of the lateral action or induction of fluids; nor did it include even every mode of producing, or every apparatus for producing, condensation in low pressure engines by means of the lateral action or induction of fluids. In short, the invention consisted of the use of the apparatus which was described in the specification for the different purposes there described and nothing more; and if any one invented a new apparatus for producing similar results, although it might be by the application of the principle of the law of induction of fluids he was at perfect liberty to do so without infringing this patent. He then proceeded to inquire whether the apparatus made by the defender, and complained of by the pursuers, was within the description and specification of Morton's patent. His Lordship read portions of evidence, and stated that the witnesses for the defender seemed much better acquainted with the engines at Addiewell and Fauldhouse, alleged to be infringements of Morton's patent, than the witnesses for the pursuers. These witnesses proved conclusively that the condensers at Addiewell and Fauldhouse were very different from Morton's patent, and corresponded very much with the general description of the blow-through condenser. But the pursuers also alleged that there was an infringement of the patent in a small experimental engine in the fitting shop of the defender, and in regard to that point he gave the following direction:—If the jury were satisfied on the evidence that the apparatus used in connection with the small experimental engine in defender's fitting-shop in Kilmarnock was so used by the defender only in private, and for the purposes of private study and experiment, that was not an infringement of the patentee's exclusive privilege within the meaning of the pursuers' issue, even though the apparatus so used were substantially the same as the apparatus described in the patent specification. Adverting to the counter-issues, his Lordship stated that if the jury found that the apparatus objected to was made by the defender before Morton's patent was secured, and that its experimental use was known to Morton, and if it was the same thing as Morton's patent, Morton's patent would be bad; but, on the other hand, if that were not the same thing as Morton's patent, then the question remained, was it the same apparatus now in use in the defender's fitting-shop? It was for the jury to weigh the evidence as to whether the injector claimed by Morton in his patent specification was new or not. If it was new, it was right that Morton should have the benefit of it; but if it was not new, then the whole patent would be lost; for if a man claimed anything that was not new within his specification, he lost the whole, until he went back and disclaimed that part that was not new, and kept the rest of his patent.

The jury retired about ten minutes to six, and, after an absence of an hour, returned the following verdict:—"The jury find that, under the issue for the pursuers, the letters patent have not been infringed at Addiewell Oil Works, at Fauldhouse pit, or foundry engine at Kilmarnock; but that the patent has been infringed at the large engine in the fitting-shop of the defender's works, Kilmarnock. The jury find that the improvement in the Giffard injector is a new invention, as is claimed by the pursuer, Mr. Morton, in his specification; and they find for the pursuer under the three alternative issues for the defender."

Counsel for the Pursuer—The Solicitor-General Mr. Moncrieff, and Mr. Mackintosh. Agents—Messrs. Hamilton, Beatson, and Kinnear. W.S.

Counsel for the Respondent—Mr. Watson and Mr. Balfour. Agents—Messrs. Macnaughton and Finlay, W.S.

THE FUTURE PROSPECTS OF THE CIVIL ENGINEERING PROFESSION, AT HOME AND ABROAD.

By G. J. Crosbie Dawson, Assoc. Inst. C.E., Vice-President of the Civil and Mechanical Engineers' Society, &c. *

To begin at home,—our future prospects in old England, I regret to say, are not so bright as they might be. There is at present a great stagnation in all branches of civil engineering.

It is quite depressing to walk down Great George-street, Duke-street, &c., of a November evening, and see all the windows dark, and offices shut, where but a few years ago, there was, even sometimes till midnight, a perfect galaxy of light,—in fact there is less work in hand now than there has been for the last 40 years, and yet there are very many more civil engineers in the country now than there ever were before, with prospects of continued increase; almost all our eminent engineers constantly receiving fresh pupils.

There are as many as 1,632 members and associates of the Institution of Civil Engineers, being double the number there were 13 years ago, and the supply is greater than the demand. The profession would be terribly overstocked, even if works were being vigorously constructed all over the kingdom, as they were before the panic 3 or 4 years ago.

Many colossal fortunes having been made during the past 40 years, the ambitious youth, now-a-days, with a mechanical turn of mind and a taste for mathematics, thinks he can see a fortune glittering in the distance, if he is but allowed to set foot in an engineers' office. But his castles built in the air are quickly dissolved, and the would be "chip of the old block" not unfrequently (I know several instances) after serving his 3 years of pupilage, forfeits that time and his premium, and has reluctantly to seek for other and more lucrative employment.

As *Punch's* advice to young people about to marry, so would my advice be to young men about to enter the engineering profession,—"Don't!"

However as some of the members of the Civiland Mechanical Engineers' Society are either now serving their pupilage or have but recently finished it, and have no intention of "cutting" the profession, but come what may, whether for better or for worse, intend to go to work in real earnest, and persevere in the up-hill struggle, hoping for better times, I must not damp their ardour, but try and take as bright a view of the future as I dare—and as Lord Lytton says in one of his novels: "But I held the doctrine which youth deems a truth and age a paradox, namely, that in science the young men are the practical elders, inasmuch as they are schooled in the latest experiences science has gathered up, while their seniors are cramped up by the dogmas they were schooled to believe when the world was some decades the younger."

The engineer of to-day has undoubtedly a much lighter task to perform than had the engineer of old. He has not to make his own experiments and formulæ, &c.. or to grope almost entirely in the dark, and live a life of constant anxiety for the success of his undertaking, whatever it might be; for he inherits the legacy left him, has their formulæ at his finger ends, and knows all about the properties of iron, strength of materials, &c., from their experiments. He can remove all obstacles that may have led to failure in any of their undertakings, and copy and improve on all that they were successful in.

Let us now inquire into the cause of the present great stagnation in all engineering enterprises. The fact is, we have been going ahead too quickly; more capital has been expended in this country on railways, roads, canals, and all other engineering works, than in any other country in the whole world, except the United States of America, where engineers are also, at the present time, at a discount.

We have in the United Kingdom, with a limited area of 122,519 square miles, and a population of 30,621,431, 14,247 miles of railway now being worked, on which has been expended no less a sum than £500,000,000, exactly two-thirds of the National Debt, which amounts to £750,000,000.

The whole of France, with an area of 210,460 square miles, and a population of 38,192,064, has only 10,302 miles of railway, and no other nation, except the United States, has more than half that number of miles.

Classification of Private Bills deposited in the House of Commons.

Session, 1870.	
Railway Bills	94
Tramway	24
Water and Gas	56
Harbour, Dock, and Port	11
Town Improvements, Market, &c.	20
Road and Bridge	8
Miscellaneous	27
Total	240
Session, 1869.	
Railway Bills	84
Tramway	5
Water and Gas	52
Harbour, Dock, and Port	12
Town Improvements, Market, &c.	23
Road and Bridge	5
Miscellaneous	31
Total	212
Session, 1868.	
Railway Bills	104
Tramway	5
Water and Gas	48
Harbour, Dock, and Port	14
Town Improvements, Market, &c.	17
Road and Bridge	3
Miscellaneous	37
Total	228
Session, 1867.	
Railway Bills	152
Water and Gas	69
Harbour, Dock, and Port	14
Town Improvements, Market, &c.	28
Road and Bridge	10
Miscellaneous	44
Total	317
Session, 1866.	
Railway Bills	409
Water and Gas	79
Harbour, Dock, and Port	26
Town Improvements, Market, &c.	22
Road and Bridge	26
Miscellaneous	71
Total	633

* Read before the Civil and Mechanical Engineers' Society, 22rd March, 1870.

Plans deposited at the Private Bill Office.

No Lists were published prior to 1846.

Session.	Railways.	Miscellaneous Schemes.	Total Number of places deposited.
1846	718	103	821
1847	300	68	368
1848	70	36	106
1849	29	25	54
1850	19	43	62
1851	57	47	104
1852	75	80	155
1853	159	90	249
1854	135	98	233
1855	98	65	163
1856	82	40	122
1857	118	58	176
1858	83	45	128
1859	147	49	196
1860	169	63	232
1861	249	57	306
1862	178	49	227
1863	209	77	286
1864	294	95	389
1865	357	104	461
1866	334	116	450
1867	96	84	180
1868	52	72	124
1869	60	70	130
1870	57	82	139

We have therefore, hitherto, had far more enterprise in this respect than our neighbours, but unfortunately many of our railways have been constructed far too hastily, and competing lines have been made running parallel with each other, and sometimes from small towns of little importance to other towns of less. Indeed we have only to refer to Bradshaw's Railway Map, to see what a perfect network of lines we have. The consequence is that many of these lines do not yield to shareholders as large returns as the funds, and some, alas, pay no dividend at all, and but few as yet, except the trunk lines, have really been successful speculations.

Of all the railways in the United Kingdom, the shares of only 10 of them are above par, and the £100 stock of 14 of them, are below £50, 12 of them pay under 4 per cent. dividend, and 9 pay no dividend at all, and it may be years before they recover themselves.

Is it therefore to be wondered at, that the public hold back, for the present at least, from investing in new undertakings?

The *Times* the other day remarked that, "the system of driving railway enterprise forward at the cost of railway proprietors has ended, as it was always sure to end, in the destruction of such enterprise altogether. No force can be put upon shareholders now-a-days. They have been thrust, as Sir Edward Watkin explained, to the very edge of their resources, and are not merely reluctant, but almost unable, to fulfil even their existing obligations. At the same time, all other investors have been alarmed and discouraged, so that, with abundance of capital unemployed, there is no longer any flow of money to public works. To say the least, it was a vain attempt to push forward railway enterprise when it could only be prosecuted at a loss. Before long, perhaps, we shall see the prospect changed, under new conditions, to one of gain, and then the work will be resumed."

At first sight it would appear that the spirit of enterprise was again beginning to revive, for this session there are 210 private bills in Parliament, out of which 94 are railway bills, showing for the first time since the panic an increase. Last Session there were 212 bills in Parliament, out of which 84 were railway bills.

In Session 1868, the total number of bills deposited were 228, out of which 104 were railway bills.

In Session 1867, the total number of bills deposited were 317, out of which 152 were railway bills.

In Session 1866, the total number of bills deposited being 633, out of which 400 were railway bills.

For the first time, therefore, as I before observed, since the fatal year of panic, the number of deposited bills show an increase. But if we analyse this year's list of bills, we shall find that notwithstanding there are 28 more bills deposited this year than last, we shall find that out of the 94 bills deposited, 18 are for the abandonment, not the construction of contemplated works, and out of the remainder 39 are for extension of time in completing works in hand, so that we have only 37 left on the list, a large proportion of which refer only to Metropolitan schemes, so that after all, in reality there is but very little improvement this Session, though there is that little.

One project however, there is which I must not overlook, as it will be one of the grandest engineering works in the country, if carried out; I allude to the Tay Bridge scheme, North British Railway, of which Mr. Bouch is the engineer. The bridge will be nearly 2 miles in length and will consist of 70 openings; 4 openings of 60ft. span, 15 of 120ft. span, 18 of 200ft. span, and 33 of 120ft. span. The bridge in the centre will be 100ft. above high water.

The general cry of shareholders, I fear now is, "close the capital account,"—perhaps the best thing for them, though not for the engineers. However, with capital accounts closed, there will be a certain amount of work for us.

Each company must of necessity, have its "staff of engineers," to keep in repair, out of revenue, the bridges, tunnels, viaducts, stations, lines, &c. It will also be necessary from time to time as the traffic grows, and grow it must, to enlarge and rebuild stations, to widen from two to three or even four lines of rails, involving the widening of all the bridges, &c., of opening new stations between old ones now far apart, as the land gets built upon.

Our population increases most rapidly: in 1851 in England and Wales alone it was 17,927,609, and at the last census in 1861 it was 20,061,725, showing an increase of 2,134,116, and an increase of 10,905,554 since the beginning of the century, the census return in 1801 being only 9,156,171.

The decennial rates of increase per cent. since 1801 average 14; therefore next year when the census is again taken we may expect the population to be nearly 23,000,000.

This continued steady increase in the population of our tight little island, must of necessity keep calling for increased locomotion.

New sea side bathing places will doubtless spring up as Rhyl, Llandudno, &c. Towns of little importance now will probably shortly be larger and more flourishing. Immense factories, small towns of themselves, are constantly springing up all over the country, and mines, owing to the continual improvements in machinery, keep yielding up continual increase of wealth. New branch lines must be constructed, whether out of revenue or fresh capital, where they are *really* wanted, and where the shareholders, as well as the directors and engineers, feel confident of a good return for their investment.

With good management, the revenue of our existing railways *must* increase yearly as the population increases, without the working expenses being greatly increased. Trains are rarely ever more than half filled at the present time, and with a return of confidence, at no very distant period, I venture to predict, that capitalists will be again forthcoming to form new companies, and to supply the sinews of war for fresh railways, branches, and extensions, though of course with regard to the past, in a limited scale.

The growing necessities of the country will require more railway accommodation, and railways can be constructed much cheaper now than formerly. On an average a single line of railway, including land and stations, &c., can be made through an ordinary country, with due care, for about £5,000 per mile; while the average figures for the existing trunk lines, made in a most massive manner, with a view to carry an immense traffic at high speeds, stand at £33,000 per mile, the cost being greatly swollen however by the exorbitant prices charged for the land, and by the legal and parliamentary expenses. Economical construction, blended with economical management must insure success in a financial point of view, if the traffic is forthcoming.

Mr. T. E. Harrison, the eminent engineer-in-chief of the North London Railway, remarked at the Institution of Civil Engineers, about 3 years ago, during a discussion following a paper on "light railways" by Mr. C. D. Fox: that the question that evening "seemed to resolve itself into how to make cheap railways in England; and he thought there were two points which bore essentially on the cost of railways. In the first place his own experience was, with few exceptions, in all the railways he had made, extending over a period of more than thirty years, that the landowners extorted the utmost farthing they could get for their land, either by means of juries or by arbitration; and if the landowners expected railway companies to make railways into their districts, under that system, he was satisfied in future years they would be mistaken. There was one case he could refer to as an honourable exception to the course which was generally pursued. The late Lord Carlisle was very anxious to get a line from

Thirsk to Malton. He was a large landowner himself, and had sufficient influence in the district to induce the whole of the landowners over twenty-two miles of line, with only a few exceptions, to agree before the Act was obtained, because unless that was done there could be no confidence in mere general statements; to sell their land for £60 an acre, including severance and tenants' damages. His lordship himself took a large interest in the construction of the line, and he and the other landowners found one-half of the capital. Under those circumstances the whole cost of the line of twenty-two miles, including stations, was under £100,000, and it now paid about 4 per cent. The other point to be considered in connection with the cost of railways was the requirement which the Board of Trade insisted on —that, with very few exceptions, public roads should not be crossed on a level. He was satisfied the persistence of the Board of Trade in that requirement was, in many instances, quite unnecessary. In some cases a portion of country was traversed where not more than two or three carts, and very rarely indeed a carriage passed in the day, and it involved a hard contest to get a level crossing sanctioned under any circumstances. In the case of a main line of railway, and an important road, he always advocated a bridge in preference to a level crossing; but he did not think the Board of Trade exercised a just discrimination in their general prohibition of level crossings; the nature of the line, and the objects to be obtained by it, should be more carefully considered. So long as it was the rule to have no level crossings, cheap lines of railway could never be made in this country. He had been accustomed for many years past to study the statistics of the traffic of railways. In a purely agricultural district, without either manufactures or mineral productions, the calculation of what the cost of the line ought to be, to make the traffic pay, was of a very simple kind. He was satisfied that the results of actual traffic to be produced from any line of that nature were not more than from £7 to £10 per mile per week; and he took that traffic return as the basis of what the cost of the line ought to be, which, to pay 5 per cent. and with 50 per cent. for working expenses. ought not to exceed £3,600 and £5,200 per mile, respectively. Generally speaking, in this country a mistake was made at the commencement. Instead of estimating what the country was likely to produce, and then saying, unless the line could be constructed for a certain price it would not pay 5 per cent.; lines were laid out without regard to the question whether the traffic was likely to pay or not. He was satisfied, if promoters would take a more commercial view of the matter, and if the lines were constructed only at such a cost as to afford reasonable prospects of the traffic giving a fair return upon the capital, there would be found even at this time, abundance of people ready to invest their money; but when a line was made at a cost commensurate with a traffic of £20 per mile per week, whilst the actual traffic only produced £10, then, he thought, people would be acting an insane part to put their money into it."

I will now turn to light railways and tramways, and I believe we are on the threshold of quite a new era of engineering in this respect. There are rich mineral districts in all parts of the country not yet fully developed; fresh iron fields and collieries to be opened out. There are also many small towns and villages in England, some miles from a railway station, where ordinary branch lines to connect them with the main lines would not pay, on account of the small amount of traffic to be carried; and where, having made the branch, the working of it would be carried on at a loss,—the wear and tear of engines, rolling stock, brakes, rails, &c., being the same whether trains are full or empty.

Our Past President, Mr. Haughton, has told us, after analysing the Board of Trade returns, that the non-paying load of an average passenger train of an engine and tender, 7 carriages, and 2 breaks, is 116 tons, while the paying load of it would be seven tons, putting the number of passengers at 73, and including their luggage, &c.

The proportions of the paying weights of trains run in 1867 were, viz.:—

Passenger Trains—

Paying weight, 4·89 per cent. of the total weight of the train.

Goods Trains—

Paying weight, 30·34 per cent. of the total weight of the train.

Or, as Mr. Haughton goes on to say, "it takes 19 tons of train equipment to carry one ton of passengers, 2¾ tons of the same to carry one ton of goods, and in gross, five tons of equipment to carry one ton of paying load."

But, although ordinary branch railways to connect many small towns and districts to one of the trunk lines of railway, would not pay; cheaply constructed surface lines with Mr. Fairlie's engines and light rolling stock, such as have been made at Festiniog, at Mont Cenis, or in Queensland, India, Norway, &c., would yield good returns on the capital invested.

The railway from Grundset to Hammar in Norway cost only £3,000 per mile, including land, rolling stock, and stations. It is 24 miles long, passing through an easy undulating country; has ruling gradients of 1 in 70, with curves of 16 chains radius. The gauge is 3ft. 6in. The ordinary speed required by the traffic, including stoppages, is 15 miles per hour. This line, although running through thinly populated districts, already more than pays its expenses, and this system is therefore being rapidly extended in Norway. If light railways can be made in this country for the same amount of money, or even £4,000 or £5,000 per mile, including everything, no doubt there would very soon be a rapid extension of the railway system; and should the 3ft. 6in. gauge be adopted, or a smaller one, as on the Festiniog Railway, there would then be no fear of any of the heavy engines or rolling stock of an ordinary railway being used on these light railways; the permanent way rails of which would weigh about 40lbs. per lineal yard, against 80lbs. on an ordinary railway. The engines in working order would weigh 14 tons, against about 50 tons on an ordinary railway; and the bridges, &c, would be proportionately lighter.

The proposed "Cobham and Esher Railway" in Parliament this Session is to be a 3ft. gauge, and is to be worked by a Fairlie engine. The estimated cost of construction, including land is £13,000. The length of the railway is five miles, so that would be at the rate of only £2,600 per mile.

I will here give a copy of Mr. Robert Piercy's (the engineer's) estimate, as I think it will prove of great interest, being the lowest price per mile of railway on record.

Cobham Railway.

Estimate of Expense.

	Miles F. Chains.	Whether single or double.
Length of Line	4 7 9·50	Single.

	Cubic Yards.	Price per yard.	£. s. d.	£. s. d.
Earthworks:—				
Cuttings—Rock				
Soft soil	30,597	9d.	1,147 7 9	
Roads				
Total	30,597		1,147 7 9	1,147 7 9
Embankments, including roads, 6,500 cubic yards, at 9d.				243 15 0
Bridges, public roads ... None				
Accommodation bridges and works				350 0 0
Viaducts ... None				
Culverts and drains				150 0 0
Metallings of roads and level crossings, 660 superfi. yds., at 1s.				33 0 0
Level crossings, including gatekeepers' boxes, signals, &c., Number 5, at £250				1,250 0 0
Permanent way, including fencing:— Miles F. Ch. 4 7 9·50 at; Cost per Mile, £. s. d. 1,128 0 0				5,640 0 0
Stations				378 0 0
				9,192 2 9
Contingencies				919 4 3
				10,111 7 0
Land and Buildings A. R. P. 16 0 0				2,400 0 0
Contingencies				488 13 0
Total				13,000 0 0

In accordance with the foregoing details I estimate the expense of the undertaking under the Cobham Railway Bill at thirteen thousand pounds.
Dated this 30th day of December, 1869. Robt. Piercy, Engineer.

There are many out-lying small towns, villages and districts, spread over the country, now far removed from any railway station, where even very cheaply constructed surface light railways, to connect them with the railway system of the country, would not pay; but were tramways laid along the side of turnpike and public roads, with steam omnibuses as proposed by Mr. Fairlie, Mr. Page, or, Mr. Thompson, of Edinburgh, to ply on them, or with horse-power, they would prove successful. Many turnpike roads, especially in populous districts and near towns, have houses built on each side, more or less continuous, sometimes for miles together; and of course any railway in the neighbourhood would be carried across fields, out of the road, and however near together the stations might be, the population could not possibly be accommodated so well as by omnibuses running on tramways, laid on the side of the turnpike road, which would take up passengers wherever required along the line of route.

Our turnpike roads, made by Telford, M'Adam, and other skilful engineers, which throughout the country are excellent, and on which vast sums of money have been expended by the last generation, would now again be thoroughly utilised, as they were in the old coaching days, forty years ago.

I venture to prophesy that before many years have gone by, we shall have tramways, for horse-power at any rate, laid along the greater part of our turnpike roads; and they undoubtedly will prove remunerative. In England alone there are 22,000 miles of turnpike road, saying nothing of highways and parish roads. The weight of the passengers, &c., carried will be as great as the vehicle, instead of the vehicle weighing many times as much as the load. Tramways will also be of the greatest convenience to a very large portion of our population, and prove extensive feeders to our railways.

Mr. Page proposes that the tramway companies shall, in consideration of being allowed to use one side of the road for their tramway, undertake to keep the road in repair, and that after their profit shall exceed 4 per cent., a sufficient per centage to pay off the debt of the road trustees should be set aside; thus the present liabilities would be cleared, and the road trustees relieved from further expense.

He estimates the cost of a single line of tramway in England at £1,800 per mile.

The Board of Trade's Bill to facilitate the construction of tramways, and to regulate their working, which was issued this month, provides that the certificates authorising the construction of tramways may be obtained by the local authority with the consent of the ratepayers in such district; or by any person, persons, corporation, or company, with the consent of the local authority of such district.

The consent of the ratepayers to the making of a tramway shall be testified by a resolution passed by a majority of ratepayers assembled at a meeting. The bill also provides that every tramway shall be laid and maintained in such manner that the uppermost surface of the rail shall be on a level with the surface of the road, and shall not be opened for public traffic until the same has been inspected and certified to be fit for such traffic. The bill contains altogether 53 clauses.

Sir Joseph Whitworth, Bart., in the course of a speech made at the annual dinner of the Association of Foremen Engineers last month, said, that in his opinion, horse tramways were not suited to the present times, and mechanical engineers had a right to enter their protest, considering the many obstructions there have been for many years past, to the employment of road locomotives.

Mr. R. W. Thomson's road steamer, of which a long description was given in the *Times*, of February the 28th, seems to be the most practicable machine yet invented, and from all accounts appears to be a decided success, working noiselessly up a gradient of 1 in 8 and equally well on the roughest as the smoothest roads.

There are, however many objections to the use of road locomotives, and undoubtedly at present horse power would have to be employed in towns and their neighbourhood, and I think also it will be found to be more practicable and cheaper on the country roads. The omnibuses could be stopped suddenly at any moment, to take up passengers living along the line of route, easier with horses.

It would also be easier to start the omnibuses again with horses, their hoofs would "bite" against the rough roads, whereas the fly wheels of a locomotive, must have a considerable weight on them to make them take the rails, otherwise however powerful the engine, they would revolve round without progressing. Then again if horse power be used, the rails of the tramways may be made much lighter and consequently cheaper. Then also by using horses, we should do away with any non-paying weight, and economise and adapt the power to the weight; have two, three, or four horses, according to circumstances. If locomotives were used, we should have to strengthen many of the existing bridges, carrying the roads over rivers, canals, railways, &c., which would not be necessary with horse power, while by using horse power we should escape a very great opposition, and horses would prove sufficient for all requirements. A horse can draw about eight times as much along a smooth train rail, as on an ordinary road; and one horse could draw about 4 tons along a level tramway at the rate of 8 miles an hour.

A furore for tramways seems decidedly beginning to burst forth. Last Session there were 5 bills for tramway schemes deposited, while this Session there are 24 bills. The share capital of these schemes is over £3,000,000, and the borrowed money more than £800,000. These bills propose altogether about 450 miles of tramway to be laid in England, 58 miles in Scotland, and 11 miles in Ireland.

Among the proposed schemes in England, are about 145 miles of tramway in London, 162 miles in Manchester, 62 miles in Liverpool, 52 miles in Birmingham, and 26 miles in Leeds.

Lord Redesdale seems uneasy about this sudden influx of tramway schemes. He rose the other night in the House of Lords, to call the attention of the house and of the Government to the various bills lodged in Parliament this Session, for the construction of street tramways. He said "that most people now admitted, that if at the first introduction of railways, there had been some Government inquiry into the whole subject, and some definite understanding arrived at, respecting the manner in which the lines were to be laid down, a great public advantage would have been secured, and much expenditure, and many useless contests would have been avoided. It was because at the present moment a new system of street tramways was on the point of being introduced that he felt it to be his duty to call the attention of the House and of the Government to it." The noble lord wished a comprehensive inquiry to be instituted. He also thought there ought to be some suspension of these schemes until further experience respecting them had been acquired; at the same time he should certainly propose that all the Parliamentary expenses incurred by the projectros should be secured to them, and that all the plans and estimates should be available for the next Session, and he ended a long speech by earnestly hoping "That the Government would direct their attention to the question."

The Metropolitan Board of Works is also hostile to tramways, and intends to oppose all new tramway bills, until the working of those schemes already sanctioned last Session, have been tested.

But I think all opposition will end in smoke. We have had tramways successfully worked in Liverpool and Birkenhead for many years, and there is no reason why those now being laid in London along the Kennington, Brixton, Clapham, and Camberwell-roads, &c., for which powers were obtained last Session, should not be equally successful, and I think I may safely say that we shall see tramways made all over London, and even all over England, by a set of competing companies, and that perhaps the Government in the next generation, will try and buy up these tramways at a fancy price, as they have just done the telegraphs, and would like to do the railways.

Let us new consider some of the other branches of engineering.

There are many towns inadequately supplied with water, even at the present time, and but imperfectly drained; and if considered necessary now to remedy these defects, how much more so will it be in a few years time; and those towns now properly supplied with water and drained, &c., in the course of a few years will require more provision in this respect, as our population is so rapidly increasing.

Then as our population increases our commerce must increase, and we shall want more docks, more harbours, more piers, &c. Then we must remember that time tells its tale, and change and decay are always at work. What to-day is a navigable river may, in a few years' time be silted up, and would soon become unnavigable, unless carefully surveyed and sounded, to see where the sandbanks were accumulating, what parts should be dredged, where river walls should be built to divert certain currents into certain channels, and thus keep up navigation entrances to docks, &c. Even the physical features of the country slowly change; the sea encroaches on some parts of the coast, and recedes from other parts, rendering breakwaters, &c., necessary.

In reviewing the future prospects of the profession at home, we must not forget the permanent engineering appointments in this country. Every large town requires its borough engineer and surveyor, every seaport town its dock and harbour engineer, every railway company its staff of district engineers, all canals, waterwork companies, and gaswork companies must have their engineers, and the various mining companies, &c., require our aid also.

I will now briefly communicate my ideas respecting the prospects of the profession abroad; for although gigantic engineering strides have been made in most countries during the past few years, there is still much more to be done. Fifty years ago there were not any railways in the world, and now there are about 100,000 miles of them, most of which have been made by English engineers, and few without some English capital. There are, however, many countries with very little railway accommodation, and very inefficiently supplied with internal communication of all kinds, and some countries with no railways at all; and, indeed, with the exception of the United States of North America, no nation has anything like the number of miles of railways, canals, and roads that we have in England, and, if we except France, no nation has even half the number we have.

I think, without doubt, that the greatest field for engineering works abroad will be found in our various colonies, for although English engineers have as yet constructed most of the foreign railways, they will not have the chances they have hitherto almost exclusively enjoyed, as civil engineering is becoming a much more general and recognised profession in most countries than formerly, and many countries can boast of almost as clever and scientific men as we can.

Great Britain and her colonies form a very large proportion of the whole globe. We "call such a vast domain our own, that the sun never sets on our might;" and in all our colonies there is much to be done.

India, with an area of about 1,465,322 square miles, and a population of about 181,000,000, has as yet under 5,000 miles of railway, which would be at the rate of about 1 mile for every 36,200 people, while in the United Kingdom of Great Britain and Ireland there is 1 mile of railway for every 2,140 people. There are, however, several new lines of railway now in the course of construction, and for very many years to come there will be abundance of work for engineers in constructing railways, canals, roads, bridges, harbours, docks, &c., and in drainage and irrigation.

Many of the railways, roads, and other engineering works have been made by the Government, and hitherto they have given a rather unfair preference to the Royal Engineers by placing them in the more desirable positions, and by remunerating them at a higher rate. This having naturally caused very great dissatisfaction among the Civil Engineers is now to be investigated, and before long, I hope that the two services will be put upon the same footing.

I will here quote a few lines from Mr. John Bourne's letter on this subject to the Duke of Argyll:—

"The anomalous position and smouldering discontent of the Civil Engineers employed in the department of Public Works in India have for some time past been attracting the attention and sympathy of engineers in other parts of the world. Though belonging to an educated, honourable, and influential profession, these gentlemen have been treated very much as if they were the pariahs of the Indian service. Not only have military officers, without special training or engineering experience, been rated as their equals in efficiency in the conduct of public works, but in every essential point—in pay, position, pension, promotion, and leave of absence, these military tyros have been set far above the professional Civil Engineer—a partiality imputable, no doubt, to the circumstance that the department of Public Works, though dealing mainly with civil constructions, is administered by military men; and to the further circumstance that in India there is no independent public opinion to act as a check upon nepotism and injustice. These inequalities, moreover, though in their own nature sufficiently invidious and grievous, are rendered more mortifying by being exhibited before a population keenly observant of the significance of etiquette and other marks of social appreciation; and the impression has consequently arisen that Civil Engineers belong to a different 'caste' from the other officers in the Government service, and properly constitute a lower stratum of society. It is not to be expected that any class of men of conscious talent and integrity, and occupying a social position at home quite equal to that of the other officers of the Indian service, should continue to acquiesce in arrangements which they find calculated, if not designed, to effect their social degradation. Nor can it be for the advantage of the Government that this sensibility should be blunted or be soured into disaffection."

There are, of course, objections to living for any length of time in India on account of the climate, &c.; but by taking the necessary care and precautions, Englishmen may and do live there even a whole lifetime in perfect health, and the high rate of remuneration makes it the most tempting of our possessions for the engineer to seek his fortune in.

In Australia, with an area of 2,690,810 square miles, there are only about 700 miles of railway, and the number of colonists alone, exclusive of aboriginal population, is now above 2,000,000. There is undoubtedly a great field for the engineer there, with this advantage, that the climate is much the same as in England,

In New Zealand there are, as yet, very few engineering works of any kind; but the country is very thinly populated, and, with the exception of road making, there will at present, I should say, be little else to do.

The area of the three islands is 122,582 square miles and the population only 100,000, half of which are Europeans and half natives; but as the population increases, the requirements of the country will, of course, increase.

In Canada a great deal has already been done, but there is still much more required. Unfortunately, the principal railways made there have as yet yielded but poor returns, which probably may, for a time, prevent capitalists from risking more money there.

As regards other nations, the greatest possible field for engineers in the whole world would be China, if we could only persuade them to let us get "the thin end of the wedge in," and make a railway there. The area of the whole Chinese Empire, comprehending not only China Proper, but also Manchooria, Mongolia, Turkistan, and Thibet, is about 5,300,000 square miles. That part of China called the Great Plain, occupying the north-east part of the country, and extending south as far as the Yang-tse-kiang, is the most densely populated of any part of the world of the same size. In an area of 210,000 square miles there is a population of nearly 200,000,000, or 952 people per square mile.

Belgium, the next most thickly populated country, has 440 people per square mile, and the United Kingdom of Great Britain and Ireland, 250 people per square mile.

If railways were to be made over that part of China in the same proportion as in the United Kingdom of Great Britain and Ireland, that is, 1 mile of railway for every 2,140 people, there would have to be constructed no less than 93,458 miles of railway. Some of the old Chinese wooden bridges, carrying the roads over the numerous rivers in the municipality of Shanghai, are now being replaced by ornamental ironwork bridges, manufactured in England.

The Empire of Japan, including all the islands, has a total area of 170,000 square miles, and a conjectured population of about 40,000,000. It is now determined to introduce railways into the empire, and a line from Jeddo to Osaka, a distance of 300 miles, is about to be constructed by English engineers. The Japanese are adopting many European inventions, and having once allowed the experiment of a railway to be tried, there is little doubt but that, if it proves a success, railways will be constructed all over the empire.

In Russia, much is now being done by English engineers and contractors. The area of the whole empire, including Poland, Finland, the Caucasus, Siberia, and the North American possessions, &c., is about 8,580,000 square miles, and the total population about 64,000,000. The number of miles of railway already opened for traffic is about 3,826, and about 3,211 more miles of railway are now in course of construction there, viz., Sergniewsk to Yaroslaw, on the Moscow and Yaroslaw Railway, 200 versts; Schonia to Turianowno, 82 versts; Moscow to Smolensk, 257 versts; Rybinsk to Ossetchensk, 278 versts; Roslawl to Orel, on the Orel and Witebsk Line, 250 versts; Yelotz to Orel, 177 versts; Griaz to Berissoglebsk, 197 versts; Rostow to Tambow, 65 versts; Saratow to Tambow, 340 versts; Koursk to Sea of Azoff, 755 versts; Koursk to Kiew, 438 versts; Kiew to Balta, 622 versts; Krementchong to Kharkow, 247 versts; Balta to Krementchong, 150 versts; Tiraspol to Kischiners, 65 versts; Riga to Nitau, 40 versts; Finland Line, 330 versts; Poti to Tiflis, 288 versts. Besides these there are many other lines in project which will shortly be commenced, being very greatly needed.

A Russian verst equals about 1,167 yards, or nearly two-thirds of an English mile. But when all these railways in course of construction are completed, there will then only be at the rate of 1 mile of railway for every 9,000 persons.

In the Austrian Empire railways are now being rapidly constructed. The total length of miles opened in 1867 was 1,815 miles; in 1868 it was 2,920 miles, and in 1869, 3,415 miles.

The population of the whole Empire, including Hungary, Tyrol, Styria, Bohemia, Moravia, and Silesia, Illyria, Galicia, Croatia, Transylvania, Servia, Dalmatia, &c., is about 40,000,000, and the area 255,000 square miles. In Hungary the roads are abominably bad, and the railways now being made will be of the greatest service.

In Prussia there is still much more to be done. The length of miles of railways already completed is 4,278. The area of Prussia is 139,675 square miles, and the population 23,970,941.

The whole kingdom of Italy, including Naples and Sicily, Sardinia, &c., with an area of 96,578 square miles and a population of about 35,503,535, has only 3,040 miles of railway as yet constructed.

A system of railways is now about to be commenced in Turkey, and will consist of a main line from Constantinople to the Save, and of two cross lines, the one traversing the centre of Roumelia, and connecting the Black Sea with the Archipelago; the other, opening to all the agricultural wealth of Hungary, and to the richest districts of European Turkey, a direct communication with the Sea of Salonica.

In Spain there will be more work to do, when she again gets settled.

In Norway, Sweden, Denmark, &c., there is much to be done.

In France, Belgium, Holland, Bavaria, Saxony, the United States of America, &c., however, in future there will be very little, if anything, for us to do. A glance at the table of statistics I have compiled will show at once, that as regards railways, they are almost as abundantly supplied as we are.

Before concluding this paper I will make a few remarks on the probabilities of new discoveries and inventions.

If we refer to the Charter of Incorporation of the Institution of Civil Engineers we shall find that "Civil engineering is the art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation, and docks, for internal intercourse and exchange, and in the construction of ports, harbours, moles, breakwaters, and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and adaptation of machinery, and in the drainage of cities and towns."

The question is, have we as yet completely and effectually "directed the great sources of power in nature" to their utmost "for the use and convenience of man?"

In the beginning of the century the world scoffed at the idea of steam ever superseding horse-power, and little dreamt that within a few years time there would be 100,000 miles of railway laid over the face of the globe, on which trains of carriagos, filled with passengers, would he run at the rate of 30, 50, and even 60 miles an hour.

If in the beginning of the century any one had said that in the course of a few years we should be able to make electricity subservient to us, and should he able, by means of the electric fluid, to send a message from one end of the world to the other, and receive a reply immediately, he would have been looked upon as a lunatic.

No one in the beginning of the century, looking up at the dim dingy street oil lamp would have thought it possible for such a dangerous element as gas to be safely substituted for it.

If all these great changes have taken place during the last 50 years, is it not quite consistent to expect still greater changes and discoveries to be made during the next 60 years.

As a humble member of the Aeronautical Society of Great Britain, I do not *quite* despair of the possibility of successful aerial navigation, and if after this admission you put me down as touched and "flighty" in my "upper storey," you must also put me in the same category their Graces the Dukes of Argyll and Sutherland, Lord Richard Grosvenor, Lord Dufferin and Clandeboye, and some of our most scientific men, who are also members of that society.

Statistics.—1868-69.

	Area in English Square Miles.	Population.	Population per Sq. Mile.	Length of Railways in English Miles.	Population to each Mile of Railway.	Lineal Miles of Railway per 1,000 sq. miles of area.
United Kingdom of Great Britain	122,519	30,621,431	249	14,247	2,149	116·29
Belgium	11,373	5,000,000	439	1,910	2,617	167·91
France	210,460	38,192,064	181	10,302	3,707	48·95
Prussia	139,675	23,970,941	171	5,603	4,278	40·11
Italy	96,578	25,503,535	264	3,040	8,390	31·47
Spain.....................	198,061	15,673,481	79	3,331	4,705	16·81
Austrian Empire......	255,000	40,000,000	156	4,000	10,000	15·68
United States of North America	3,591,849	38,442,995	10	42,572	903	11·85
India.....................	1,465,322	181,000,005	124	5,000	36,200	3·41
Russian Empire	8,582,741	64,000,000	7	3,826	16,727	0·44
Australia	2,690,810			669		0·25
Japan	170,000	40,000,000	235	*nil.*	...	0·00
The Great Plain of China	210,000	200,000,000	954	*nil.*	...	0·00

The society has held meetings for the last four years, at which I can assure you some very clever papers have been read and ingenious and practical models exhibited, and we have had an exhibition of working aerial machines at the Crystal Palace, so we mean business if possible.

We must not forget that the Channel has been crossed in balloons, and that aerial voyages have been successfully made at night as well as day, both with and against the wind.

Mr. Monck Mason, in his work on the "Theory and Practice of Aerostation," says that to the aerial voyager "the Atlantic is no more than a simplo canal; three days might suffice to effect its passage. The very circumference of the globe is not beyond the scopo of his expectations; in fifteen days and fifteen nights, transported by the trade winds, he does not despair to accomplish in his progress tho great circlo of the earth itself. Who can now fix a limit to his career?"

This is, however, *rather* "high flown" language, as no really thoroughly perfect aerial machine has yet been made, although to my knowledge two "quack" aerial transport companies have lately struggled in vain to obtain the necessary capital to perfect their machines, and have been deservedly unsuccessful.

I think it quite possible, however, that we *may* livo to seo a perfect aerial machine, though he it be ever so perfect, it will, for obvious reasons never be used for the transport of passengers, though it may provo of great service in many ways in cases of war, shipwreck, &c., and for making scientific experiments.

Hydraulic presses, lifts, &c.; pneumatic tubes, for the conveyance of either passengers or parcels; floating docks; subways under rivers; the wire rope transport system; hot air and gas engines, &c., are inventions of to-day.

Have we yet utilised electricty, magnetism, galvanism, &c., to their *utmost?* Cannot we further "direct the great sources of nature for the use and convenience of man?"

I say undoubtedly we can, and inventions and discoveries are daily being made, as we see by the long lists published weekly in the *Patent Journal.* But the world is still as slow to believe in new ideas, inventions, and discoveries, until crowned with success, just as much as 50 years ago.

PATENT LAW.

The Bovill Litigation.

(*Continued from page* 77.)

"Mr. Justice Byles: That is an increase of 40 per cent. Gentlemen it is sufficient for me to say this, that whether you have channels or no channels, there is a blast. If you have channels in the revolving millstone there is a blast. If you have channels, as here, in tho fixed millstone, still there is a hlast. Now in this case, as I understand, we have not to consider the question of a super-added blast, and here I will read you also a passage from my brother Willes' summing up, in which he says: 'I humhly concur in the judgment of the Master of the Rolls in saying that this second part of the patent does apply to an exhaust, applied not only in conjunction with a super-added blast, but in conjunction with any blast at all, whether super-added or not;' which is extremely important because if this invention were claimed as a part of the invention where the super-added blast is added, and only in that case, then it may be that this specification would be entirely inapplicable and the increase of the hlast inapplicable too. So that you see the second claim should seem to be, exhausting the dusty air blown through the grinding surfaces from the stone cases to the extent of sucking away the plenum through tho stones and that only. They say it you suck more you do a great deal of mischief, if you suck less you do no good, and the word plenum includes a fulness produced whether with or without the super-added blast. Therefore, gentlemen, I tell you as a matter of law that the plenum here means a certain quantity of air which is there—the excess as it seems to me—I do not say that this is quite right, but it is as near as I can come—the excess above what would be there if there were no currents. Everything that is above the density of the still air is plenum.

"Now I come to the third claim, which also is a claim very important for your consideration. 'I claim the passing of the dust or stive caused in the process of grinding through suitable porous fabrics, hy which the flour is filtered from the air as herein described.' Now in order to see how narrow or how wide this claim is we will go hack to the specification again and see what he says about that. 'The third part of my invention consists in straining the stive or air which is surcharged with fine flour through suitable porous fabrics which retain the flour and allow the air to pass through; and this I accomplish by exhausting the air from the millstone case or other closed chamber receiving the meal from the stones by meansofa fan or other exhausting machinery, and blow the stive so exhausted into a chamber.' Your will obseivo we have only just now arrived at the chamber. He states many processes before you get to the chamber which makes my brother Willes say: 'My impression is that this is a claim for getting the air into the chamber in the manner there described.' It might not therefore apply to any chamber. Pardon me for reading it once more to enable you to apply the evidence:—'The third part of my invention consists in straining the stive or air which is surcharged with fine flour through suitablo porons fabrics which retain the flour and allow the air to pass through; and this I accomplish by exhausting the air from the millstone case or other closed chamber receiving the meal from the stones'—that is the same thing; probably it may he that in one of tho patents, I think it is Damy's patent and another, whero there is a circular chamber, that may come within his definition, but that is immaterial—'by means of a fan or other exhausting machinery, and blow the stive so exhausted into a chamber having its sides and top formed of one or moro thicknesses of suitable porous fabrics, to allow the air under pressure to pass out, deprived of the flour, by means of this filtration. I also obtain the same result by placing the filtering chamber between the stone case or chamber receiving the meal and dust from the stones and the exhausting machine. The stive, or dusty air, is then sucked through the filtering fabrics, instead of being blown through, and the air passing away clean as before.' With that, let us read again the third claim. 'And lastly I claim the passing of the dusty air or stive, caused in the process of grinding, through suitable porous fabrics, by which the flour is filtered from the air as herein described.' Now, gentlemen, that is, as succinctly as I can give it you, my opinion of what those claims mean.

"Now I come to the part of the case which is for you and not for me.

What was done before this patent to anticipate it, and make it bad? As I have already said, you will bear in mind that mere experiment or unsuccessful user is not an anticipation; still less is the impossibily of a man doing that which he did not do—that is not an anticipation. If he had a machine which did do the thing, and he did not do it, and knew nothing about it, this being a patent for a process—that is not an anticipation.

"Now, gentlemen, the first witness that was called was Mr. Bovill. I will direct your attention at some length—although I do not propose to read the whole of it unless you insist upon it—to Mr. Bovill's evidence. The other witnesses I shall go through much more shortly. I will read the evidence of the first and second witnesses for the plaintiff and defendant, which will give you a general view of the case; and with respect to the contradictions, I shall make a remark or two, but shall refer you back to the observations you have heard at the bar; for you have heard both sides, which in all disputable matters—which almost all matters are—is the only means of arriving at the truth. Mr. Bovill describes himself as a civil engineer; he had a large establishment at Millwall, and he says: 'In 1845, I used to make milling machinery.' Then he describes the size of the stones, which it may be some use to remind you of—4ft. 6in. in diameter, and about 9in. thick, and that they weigh about a ton each. One question which may be material here, though chiefly with a view to the construction of the patent is, what sort of wind would be caused by the rotation of the stones. The stones rotate, as I understand it, 1,400ft. or 1,500ft. in a minute, at the circumference. The grinding face is cut with furrows. He then describes some of them as leading into the eye of the stone, which are called master lines, and others obliquely to them; and then he shows you the mode in which he cut his furrows in the upper fixed stones. He says, 'formerly the upper stone rotated, and then it was apt to go from side to side, and would not always keep a perfectly horizontal surface.' He says both the stones were cut in what he calls the 'land,' which as I understand is the surface of the stones, and that they are so cut that these lines in the stones cut the grain like a pair of scissors. 'The corn enters at the eye, which eye of the upper stone, whether fixed or running, is about 10in. in width, either by a feed-tube or by the hopper' which is called a damsel, I suppose because it waits upon the creature beneath. 'The corn is drawn in by the indraught.' Observe what a draught there is by the natural state of things—'the corn is drawn in by the indraught, and the centrifugal action of the stones. The way the grain goes in this machine is in continually increasing spirals till it is thrown out; and it is worked by the centrifugal action of the stones, and the blowing action of the furrows. The meal is delivered at the circumference and the furrows of the stones act like the fans of a blowing machine.' That is important, or would be if the question to which it relates was a question for you, but it is rather, as I judge, a question of law. 'The furrows of the stones act like the fans of a blowing machine; they blow out the meal; the air is supplied at the entrance of the eye; the upper stone is cut; the furrows cross each other like a pair of scissors; the stones do not touch each other; there is between them the thickness of a piece of bran or very thin paper; they ought not to wear at all'—but they do wear, and although they wear you cannot get the meal clean—the meal sticks to the bran be says—and there lies the profit of the miller according to him. Take care, let bran be bran, and not flour, which in the case of an extensive business like Mr. Potto Brown's means a great deal in the course of the year. Mr. Bovill is asked to describe the inconveniences which preceded his patent. He says first of all—there is heat from friction. If beat ended in heat I suppose that would do no harm, but the heat superinduces the precipitation of moisture, and then comes moisture. There is already 16 to 20 per cent. of moisture in all English wheat; and the air is converted by the action of the stones into a steamy moisture, and the temperature is about 100°. In another part of his evidence he added, and even there again he says—'It produced a clamminess between the stones, it choked up the fineness of the furrows, and pasted the stones, so that sometimes it was necessary to take them up. When once the stones begin to get clammy they must be taken out and cleaned. Fine flour is impeded in its progress towards the periphery, and fine flour has its quality deteriorated' (to use his expression) 'by being mashed up, and when it comes out it is wet and clammy. The case is about 4in. from the stone. The flour always came out clammy. It had to be kept for a week before it was dressed.' There is a good deal of evidence in the course of the case. I being entirely ignorant of these matters did not know it before—that people do keep their flour for some little time before it is dressed. On the other hand it is said that by this apparatus you may dress it conveniently, and dress biscuit flour. It descended by a meal spout; and that you have seen and understand much better than I do—'the meal falls out at the spout.' Then he is asked what is stive—and says, 'stive is foggy atmosphere; it is air charged with fine particles of grain.' He tells you the quantity to which I have already called attention, with a view of showing you what a natural blast there is. 'The quantity of air blown through without any artificial blast, when the stone is grinding, is about 950 cubic feet an hour in a four foot stone.' Then he goes on to detail to you what I did not know before, I am sure, which I have no doubt is a very important improvement to whoever gets rid of the mischief—namely that the mills are unhealthy. He says there was scarcely a miller of 60 years of age under the old system; and that people who had been working in mills go to snuff mills, in order that the less agreeable action of the snuff as compared with flour may tend to remove the inconveniences—they are obliged to take refuge, as it were, in snuff mills. Then he says, 'the flour is separated from the offal through wire cylinders—the meal is put inside and driven out by brushes through the wire—small particles of bran get there. Sometimes it was necessary to dry it before exportation. In 1846 I brought out my first patent'—to which you will have your attention called shortly—'I purchased M. Bouglcaux's moiety of the patent for £10,000. I took it out at my own expense, and I bought his share. There is an artificial blast down the eye of the upper stone, making it go along the grinding surfaces in the lands. The particles were made fine enough to be blown out directly. That got over the wet clamminess and pastiness, and improved the quality of the flour.' Now comes an important answer for your consideration, if Mr. Bovill is correct—'The dust and stive instead of being made better was made worse.' He says that dust and stive was aggravated. Then he goes again to France—I do not know whether he had been there before—but he goes to France and made many other experiments. He visited D'Arblay's mill at Corbeille; he stayed some days, and saw nothing there which led to the patent. That is an answer no doubt which has an indirect bearing on another part of the case, because D'Arblay's patent is one of those which they say is an anticipation.

"Mr. Webster: D'Arblay's mill, my Lord."

"Mr. Justice Byles: You did not say the patent was D'Arblay's mill."

"Mr. Webster: D'Arblay's mill."

"Mr. Justice Byles: Then I say no more.

"He then explains at length the patent of 1849, and says there—"I drove the bottom stone instead of the top stone—the top stone often failed. I had to remedy the heat, the friction, the pastiness, the obstruction in the air. I put pipes into the upper fixed stones—as many pipes as furrows. I put no pipes in the master lines—some millers use more, some less The lower stone had no eye.' Exhaustion (as we all know) is an inverted blast—you suck in the meal with the air. You have a plenum, or may have a plenum without any super-added blast. That is rather a question of law than of fact, and I tell you that this is the construction of the patent. I do not know that I need read any more of his evidence there. As to his second claim he says—'An air spout conducts to an exhausting machine which leads to the stive chamber. The sides are of porous material. The same fan which acts as an exhausting instrument from below is a pressing instrument from above.' That we know. If there is excessive exhaust, the meal is drawn out which produces more waste than before. That is, the reason for confining it to the plenum. He says—'If it is excessive there is more waste than before. It now allows us to work with an open meal spout. It has this further effect, it holds up the meal in the meal spout, and will not let it come down. There is an exhaustion—that is, exhaustion which is a vacuum. However fine the fog may be, nothing is let through but atmospheric air.' I presume that is from the stive chamber. 'It is brushed down once a day. Now there is no paste in the meal cases, or between the stones or any part. The heat was 20° to 30° less, the meal is drawn out dry and fresh; it may now be dressed through French silk, which before it could not, our climate being more unfavourable than France, and the condition of the wheat more unfavourable than France for such an operation.' He says, 'I do not say it was the patent of 1849 that enabled me to do that—I could do that well enough by the patent of 1846, if it had not other disadvantages. I had never seen the dressing machine before 1847 or 1848.' As I told you, utility is not here in question; but utility may reflect light upon novelty. Then he said, "I induced the Government to use my patent, and my patent is now adopted for Government experiments. It was discussed in the House of Commons and in the House of Lords, and there was a trial in the case of Bovill *v.* Keyworth.' Then he described an unfortunate state of health into which he fell, which was possibly introduced—although I do not know that that was the reason of it—to explain his inaction during some of the periods in question. That is a long way off this inquiry. He is then cross-examined, and he puts in a circular in which he advertises his invention to the world, and states the advantages of it in the mode above described. I do not know that I should advance the case by reading again that, the substance of which I have already told you, but if you wish to know what Mr. Bovill's notion of the merits of his invention are, which of course would not be less than the invention deserves, you have nothing to do but look at this—it may serve to refresh your recollection. He says, 'In No. 1 of these is a super-added blast; and in No. 2 no super-added blast.' He says he was ill from 1853 to 1862. I am now upon his cross-examination. In 1864 suits were instituted in his name—that was during his illness—'I claim the royalties for six years gone by,' which no doubt is a serious claim. Then on the other hand there is a combination to meet him. There are or were, for whether they exist still I know not, a combination of 79 members of the trade at Manchester to oppose him. 'There have been about 100 suits—I have been forced to litigation. I have endeavoured to consolidate the suits. The whole of the Manchester people have yielded. My claim would be over £100,000.' Then he is cross-examined as to No. 1 and No. 2 drawing, and then he comes to the Scotch patent of 1846. I do not think I need read to you at present any part of his evidence upon that subject. As to his other claims, the material part of it is—I endeavoured to abbreviate it; but I am afraid there is a good deal of it we must not leave out. I come to the Scotch patent of 1846, and he says, as I understand him, both with respect to the Scotch patent of 1846 and the English patent of 1846 (certainly with respect to the English patent of 1846) it will not work. He is then cross-examined at great length with respect to Cartier's patent, and other French patents; and I will advert to that part of his case when I come to deal with those patents. At the conclusion of his examination he says, 'When the exhaustion of the plenum only is applied, the resistance of the plenum or muffle to free exit of air is removed, and the stones, having no resistance to meet, the blowing action discharges 40 per cent. more air. I never heard, and I never read of any exhaustion of the plenum and that only.' *I never heard, and I never read of any exhaustion of the plenum and that only.* That means before my patent. 'If the plenum is to be exhausted, and neither more nor less, there are various ways of doing it. The miller would effect that by a fan,' &c.

"Then he is re-examined. Having been asked about the stive, and so on, of course that opens the mouth of Counsel on re-examination, and he says, that of these 100 suits, 27 or 28 have come into court. 'As to all the others, except this which is now under consideration, all the decisions have been in my favour. In all the others the defendants consented to a verdict and paid damages. There has been no compromise by me in any case, and in every case I have had substantial damages; and there are 14 or 15 cases now pending.' You have therefore his view of the case. His notion was undoubtedly—and in that he is right—that he proposed to suck out the plenum, and the plenum only; and that answer is most material when we come to consider the question of anticipation.

"Now I pass over a great deal of his evidence, because if I were to read you the whole of this evidence the only consequence would be that we should be involved in extreme confusion; and you would be tired in a very short time. But I will refer to it again by-and-bye on other parts of the case; briefly, however, it is only with three or four witnesses I mean to trouble you at this length; it being of no use whatever. On the contrary, it would divert your attention from the real merits of the case on one side or other, where I to do more than I propose to do. However, he calls a gentleman of the name of Miller, who is chief engineer at the steam yard at Deptford. He says he tested this at Deptford with two other gentlemen—one is dead, and one is paralysed, and therefore they cannot be here. 'The meal as now used in these establishments is delivered cool. The grinding is more rapid. You can make the meal at once into biscuits for the sailors.' He is the chief engineer of the steam yard at Deptford, and he is asked—'Did you ever know of any apparatus like this?' He said, 'I had never seen it, or anything like it, until 1852. I tested other mills, but I never heard of or saw any machinery like Mr. Bovill's.' Since then, Mr. Bovill's machinery has been used in the Government mills. The fact that it has been introduced into all the Government mills is relied upon, I suppose, as evidence to show its utility; and therefore, as I said before, and no otherwise, reflecting some light upon the novelty.

"He then calls Mr. Fothergill, a consulting engineer at Manchester, and who describes himself as a juror at the Exhibition of 1851 and 1862, and therefore I suppose a person who understands these matters, He says in no previous patent has he discovered any anticipation—the ventilation, the exhausting, the plenum, and the stive room he then speaks of. He says the plenum may be produced by an artificial blast, but it may also be produced by the ordinary action of the stones. It escapes from the meal spout, and when it is open it comes back into the mill. The warm air and stive went over the meal. The meal was heated, and there was heat and damp. Then he says, 'There is now no such effect of heating and clamminess about the mill or the waste;' and he says, '900 cubic feet per hour passed between the grinding surfaces of the stones before, and now there are 1,260 cubic feet pass, making a difference of 40 per cent.' He then calls Mr. Trevethic, who is a practical miller, and was 35 years ago in the employment of several large millers—he says: 'I never heard of such improvements as Mr. Bovill's before his patent.' He is cross-examined, and says he has had no experience of the exhaust fan, nor of the stive, through French silk, or through porous fabrics, nor of its being dressed.

"Now, gentlemen, that is, as shortly and briefly as I dare give it you, the evidence for the plaintiff. The plaintiff says that from his evidence he has shown that the first combination is new, that the exhausting the dusty air from the stone cases to the extent of the plenum is new and highly beneficial, avoiding injury on either side; and that passing it in the way he describes through suitable porous fabrics effectually filters the air from the meal—that s an outline of the plaintiff's case and but an outline.

"Now the defendant calls a gentleman of great scientific eminence, Mr. Bramwell. Mr. Bramwell for several years managed the works of Mr. Bovill and his partner just prior to 1846, and therefore I suppose was in the employment of Mr. Bovill at the time when the patent of 1846 was taken out. Then he is asked whether he has inspected the defendant's mill; and a model is produced of what the defendant has done. As to that model, there was a difficulty made about receiving it. I had a doubt whether it could be received, because the infringement is not in question here, as it often is in patent cases; but the Master of the Rolls is satisfied about that, and does not ask you upon it. However, I endeavoured to learn from my brother Willes what was done on a former occasion, knowing that I could not follow a safer authority. The model is produced before you. After describing that, he comes to the anticipations which are really the great things. And first the Scotch patent, which you know differs from this patent in this—*inter alia*—it has no plenum; there is no direction to exhaust the plenum. Then he is asked about plenum. He says, 'I do not think *excess* is the proper word, and I do not think *plenum* is the proper word; I think it means *fulness*, which as I have already said is merely English for Latin; but still it does explain somehow or other more distinctly what is meant and what I mean.' He says that, 'that Scotch patent was perfectly efficacious, it increased the pressure in the case to a very small extent. There must have been a little excess'—that is still meaning, by 'an excess,' the plenum, as I suppose. 'It increased stive in the mill.'" This is not upon cross-examination, this is upon examination in chief. 'Formerly there was only one spout for the meal and the stive—stive is caused by action of mill stones in all cases. There was a separate exit of the stive as early as 1846. It was first new in the French model. If you remove the stive room, the whole of the rest is the same.' I presume this is on comparison with the French Model. 'An open spout, a meal spout, mill-stones in both; meal case with hat between the case and the top of the running stone, the exhaust fan connected by exhaust pipe to the mill-stones below. The Scotch patent and this are identical except the stive room.' Therefore it appears, by Mr. Bramwell's evidence, that in respect of the stive room, the Scotch patent, as I understand him, does not conflict with this patent. In the case of a super-added blast, which would take away the plenum and nothing more, you get an excellent result which cannot be improved. By way of precaution a little more is usually taken to ensure that you do not get dust into the meal. With a super-added blast the meal is aerated. It does not therefore require further aeration by the action of the exhaust. All that you require is, to prevent the nuisance of dust in the meal. Within the exhaust you must have got away something more, so as to produce a current of air up the mill-stones, and as the meal falls down the spout it meets the ascending current and therefore is aerated and dried. The apparatus of the Scotch patent is the same as that in question.' I have called your attention to the Scotch patent, I will leave what he says about Cartier, Vallod, and Damy until another part of my address to you, when I call your attention to those patents. I rather think there is something said by this witness as to what he said before, but I am not sure that I can find his answer. Was he examined in Bovill v. Keyworth, Mr. Grove?"

Mr. Grove: Yes, my Lord.

(*To be continued.*)

THE METROPOLITAN DISTRICT RAILWAY.

The portion of the Metropolitan District Railway which runs under the Thames Embankment is now being rapidly pushed forward to completion, and it is expected that the line from Westminster to Blackfriars-bridge will be opened for traffic before the end of this month. The new section will present some peculiarities of construction, required by its relations to the roadway of the Thames Embankment and to the Temple; and in the immediate neighbourhood of Blackfriars the works have been carried on under conditions of considerable complication and difficulty. Westminster-bridge Station, the present terminus of the railway, was not originally completed for its full length on account of the delay which occurred in gaining possession of the necessary lands which were owned by the Board of Control, beneath whose property the platform will extend some 50ft. or 60ft. From the end of this station the line is covered in for a short distance by iron girders placed obliquely, and connected by brickwork, this portion being destined to support a garden attached to the offices of the Board of Control. From thence the ordinary arch-covered way extends for 130 yards towards Charing-cross, when the line enters upon the Embankment, and the single arch is replaced by a flat roof, formed of transverse iron girders placed about 8ft. apart, with shallow brick arches between them, and supported on brick walls 13ft. 6in. in height, the south of which is in contact with the concrete of the Embankment. 515 yards of this construction reach to the beginning of the Charing-cross station, itself 100 yards in length, and on leaving the station the roadway will be open to the air for 200ft., the opening being 10ft. wide. Then 688 yards of girder-covered way bring the line to the Temple station, which is in the space corresponding to the interval between Arundel-street and Surrey-street. In the middle of the Temple station it leaves the Embankment to the southward, and, still retaining its girder roof for 136 yards, is once more covered in by a single arch, where it passes through land belonging to the Temple. This portion is 259 yards in length, and when it is passed the girder construction is continued, with a single twelve yards of opening to the Blackfriars station, which is immediately to the eastward of the new bridge. The total length from the middle of Westminster station to the middle of Blackfriars station is 2,200 yards, and the stations are very nearly equi-distant. The girders that sustain the roof are usually 2ft. 6in. in depth, and about 8ft. apart, but where they cover sidings and wider portions of the line they are 2ft. in depth and are set more closely. They are about 600 in number, and have an average weight of four tons and a quarter, so that about 2,500 tons of iron are employed in this manner.

The railway, in quitting Westminster-bridge, descends for some distance with a gradient of 1 in 60, until reaches the normal level, about 4ft. above Trinity high-water, which is preserved until the scanty headway under Waterloo-bridge renders necessary a fall of 1 in 40, and a corresponding rise on the other side of the bridge. The roadway from that point remains on the level until, at the eastern end, a rising gradient of 1 in 40 leads it to Blackfriars-bridge.

It has been found that on the older portions of the line, the edges of the holes in the steel rails have grooved, and in some instances have almost divided, the iron bolts by which the rails are secured to the sleepers. To obviate this for the future, a steel collar is now shrunk on to each bolt, immediately below the screw that holds the nut, and in this way, by opposing to the rail a metal of equal hardness with itself, it is found that excessive wear may be prevented. Within the precincts of the Temple, as a precautionary measure against the interruption of legal studies by noise and vibration, the sleepers rest upon a layer of tan, six inches in thickness, placed immediately below sand ballast. This arrangement has already been adopted, and found to answer well in the neighbourhood of Westminster Abbey, and the Benchers of the Temple made its employment one of the conditions of their approval of the line.

About fifty yards west of Blackfriars-bridge, the railway is crossed by a tramroad for the conveyance of coals from the river to the works of the City Gas Company; and, nearly at the same point, the subway of the Embankment rises to the surface. The low-level sewer crosses obliquely beneath the railway; and the Fleet will cross beneath it at right angles, to open into the river under the first arch of the bridge. The difficulty of finding room for all these requirements has been very great.

The original opening of the Fleet was immediately to the westward of Blackfriars-bridge; but its new opening will be in the centre of the abutment of the bridge. In the last part of the new course there will be an elaborate arrangement of flaps and penstocks; and, while this is under construction, a new and temporary channel or diversion has been made, leaving the Fleet at an angle, passing under the Blackfriars station, and opening into the river to the east of the bridge. Beneath the station it has been found necessary to lower the level and contract the area of this diversion; and for this purpose another diversion was made to the eastward of the first, leaving it to the north, and re-entering it at the south of the station. When this was completed, the portion of the first diversion that passed under the station was converted into a barrel drain by iron tubing seven feet in diameter; and then the second diversion was closed. The low-level sewer passes beneath the barrel drain, and will eventually be connected with the Fleet channel, so as to relieve the latter of some portion of its contents. The tramroad to the gas works passes under the roadway of the Embankment, and over the railway at a sharp angle; and the subway of the Embankment is also carried over the railway.

The entrance to the new terminal station will be close to the commencement of Blackfriars-bridge, on the east side. Its platform and general arrangements correspond closely to those of Westminster, and all the ordinary stations of the line. By means of this station the inhabitants of the west end of London will be enabled to travel by rail to within less than five minutes' walk of St. Paul's; besides which it serves as an exchange station for the London, Chatham, and Dover Railway.

ON THE MERCANTILE AND ADMIRALTY RULES FOR CALCULATING THE POWER OF MARINE STEAM ENGINES.

By Robert Armstrong.

The almost universal employment of the steam engine for impelling machinery, and in ocean navigation, renders any question relative to its more economical working a subject of national importance, and one which has always commanded the attention of the members of our scientific institutions when brought before them.

The object of this paper is to call in question the accuracy of the Admiralty rule for calculating the nominal and indicated horse-power of the steam engine, and to show that the higher velocity of the piston in the engines of H.M.'s navy is not attended with results proportionate to their first cost, and such as to justify the increased wear and tear of the machinery as compared with the practice laid down by the mercantile rule.

These two rules are so well known that a very brief recapitulation of their theories is necessary, to show that they are so diametrically opposed in principle; that one of them should never have been entertained under any circumstances whatever.

Both of these rules have been advocated by engineers of the highest authority in their profession; the earlier of the two, or mercantile one, was established by Watt, and is still retained as the best practice for stationary and paddle-wheel steamers, and was employed in the case of the screw propeller by our most celebrated firms to within the last twenty years, since which time the Admiralty rule has been adopted without parentage.

The principle of the original one, called the slow speed or mercantile rule, has been so well defined by Tredgold that I cannot do better than employ his own language in explanation—"In steam engines there is a certain velocity for the piston which gives a maximum quantity of useful effect; as at the greatest possible velocity an engine has no useful power, and, on the other hand, if the resistance be equal to the pressure of steam it will have no velocity, there must be an intermediate velocity, which is the best possible for the engine to work with; therefore the velocity which corresponds to the maximum of useful effect is twice the square root of the length of the stroke in feet per second." Say a velocity from 180 to 200ft. per minute.

In explanation of the Admiralty rule which assumes a velocity of piston of 400ft. per minute; we have instead of argument, the assertion of Rankine, Russell, Bourne, and other writers on the steam engine, "that the limitation to old rate of speed has been shown to be groundless, and that the power of the steam engine, is the force and space passed over in a unit of time; and that in marine screw engines, and in locomotives, speeds of pistons are used ranging up to 900ft. per minute and more with advantageous results." To reduce these two principles to their briefest definition, the mercantile rule asserts, that the mechanical effect of a pressure of steam is limited, and its maximum work arrived at, when the velocity of the piston reaches say 200ft. per minute. While the Admiralty rule, theoretically makes the mechanical effect (work) of a pressure of steam infinite. In a pecuniary point of view a 500 nominal h.p. engine by the mercantile rule, would if purchased by the Admiralty rule be equal to 1000 nominal h.p., or a difference to the purchaser of £25,000, allowing £50 as the price per nominal h.p., consequently entailing a difference of several millions sterling, in the whole of H.M.'s Navy since the adoption of the Admiralty rule. Moreover, as the working velocity of the piston in the screw engines in the navy is about double what the old rule asserts is sufficient, we may safely aver, that the losses from the increased wear and tear of the machinery, and the consumption of fuel are in the same proportion.

With such a divergence of opinion between the old and modern practice the momentous question arises, which rule is the correct one?

To solve this important problem, we can only appeal to facts, and compare the performances of vessels, in which there is a sufficient variation in the velocity of the piston to test these two rules.

For this purpose, the British Admiralty have furnished more than 1,000 trials of steamships, the data having been collected by the officers of the Admiralty with the greatest care that human ingenuity could devise, the whole containing such a variety of mechanical experiment, with different propellers, such various velocities of piston, ranging from 150 to 500ft. per minute, and other valuable data as are amply sufficient to enable the mathematician to ascertain which is the correct rule.

For this purpose I beg to call the attention of those who have perused the data alluded to, to the two columns of co-efficients at the right hand side of the results, which show approximately the relative excellence in respect of speed, of the forms of the various vessels, conjointly with the relative efficiency of the steam engine and propeller, as adopted to each of them, these co-efficients having always been accepted as a correct mathematical expression of the combined vessel, engine and propeller.

The formula, $c = \frac{\text{Mid Section} \times V^3}{\text{I. H. P}}$, by which the co-efficients are produced is so well known and correct in theory, that no explanation of it is required, and which I have adopted for the primary investigation.

In the comparison of the co-efficients I am about to make, the Admiralty have furnished the figures by which the first step is taken in proving the correctness of the mercantile rule. In proceeding with this analysis I have selected the trial trips of the same vessel with the same propeller, and where there is a variation in the velocity of the piston so that the efficiency of the propeller or the form of vessel cannot enter into the comparison of the co-efficients, therefore the co-efficients only apply to the efficiency of the steam engine in the vessel. I may here premise that the higher the co-efficient the greater the efficiency of the engine at that particular trial.

The trials and data are taken from Mr. J. S. Russell's work on naval architecture, where the data are given of two or more trials of the same vessel, to which I have added the velocity of the piston. Therefore, in the perusal of the co-efficients it will be seen how universally, and without exception, the correctness of Watt's rule is confirmed by the vessels always producing the highest co-efficient when the velocity of the piston is diminished.

	Revolution of Engines.	Velocity of Piston. Ft. per second.	$V^3 \times$ Mid. Sec. / I H P.
Assurance	49	6·60	638
	46	6·22	658
	37	5·00	737
Assurance	89	5·93	380
	73	4·88	506
Black Prince	56	7·46	554
	54	7·22	603
	47	6·23	674
Caledonian	57	7·60	556
	45	6·00	616
Cameleon	97	6·48	416
	80	5·33	603
Donegal	54	7·20	550
	47	6·28	592
Esk	69	6·32	562
	55	5·04	693
Hector	59	7·86	636
	48	6·40	710
Himalaya	56	6·53	680
	45	5·25	720
Hornet	78	5·20	507
	71	4·73	647
Howe	57	7·60	523
	45	6·00	607
Immortalité	55	6·41	590
	46	5·36	699
Landrail	90	4·00	466
	70	3·10	618
Liffey	54	6·30	571
	44	5·13	683
London	60	6·07	623
	49	4·90	719
Malacca	94	6·79	546
	81	5·85	690
Ocean	58	7·73	588
	47	6·26	638
Phœbe	62	6·20	548
	50	5·05	670
Prince Consort	56	7·53	615
	55	7·33	627
	43	5·80	729
Research	85	5·66	490
	85	5·66	500
	69	4·60	524
	64	4·26	564
Royal Oak	60	8·11	610
	59	7·97	582
	47	6·33	670
Scylla	56	6·06	518
	45	4·87	611
Warrior	54	7·23	659
	44	5·93	767
	38	5·06	824

(To be continued).

COMPETITIVE TRIAL OF STEAM FIRE-ENGINES AT GLASGOW

The most important competitive trial of steam fire-engines that has occurred since those made at the Crystal Palace in 1863, took place at Glasgow on the 18th of March. The civil authorities of that city issued an advertisement on the 1st of October last for a steam fire-engine, and two were offered to them, one being from Messrs Shand, Mason, and Co., and the other from Messrs. Merryweather and Son, both of London. A competitive trial of these engines was then proposed and agreed to; and the report of the judges appointed—Mr. Connor, of the Caledonian Railway Company; Mr. Moore, hydraulic engineer, of Glasgow; and Mr. Bryson, the chief of the Glasgow Fire Brigade—says:—

"The engines having been taken from the Fire-engine Station to weighing machine at foot of Dixon-street, fully equipped, were found to weigh (by certified report from weigher) as follows:—Shand, Mason and Co.'s engine, 42 cwts. 3 qrs. Merryweather and Son's engine, 48 cwts. 2 qrs. The engines were then placed in position ready for testing, their suction pipes for drawing water being put in the river Clyde. To each engine was attached 280ft. of delivery hose, supplied by their respective makers. The nozzles were, for Shand, Mason and Co.'s engine, No. 20, equal to 1 4-16in. Merryweather and Son's engine, No. 21, equal to 1 5-16in. These branch pipes were then laid upon a frame erected for the purpose, both being at the same angle, and securely lashed to said frame. All being in readiness the word to commence firing was given at 12 hours 51 minutes, and in 9 minutes 45 seconds Shand, Mason and Co.'s engine commenced working, with gauge showing 100lb. pressure of steam per square inch. Merryweather and Son's engine commenced work in 10 minutes, with steam at 100lb. pressure per square inch, as indicated by gauge. Both engines were then put under test No. 2, so as to show the greatest distance water could be thrown horizontally. During this test notes were taken repeatedly and accurately of the distances each engine was throwing the stream of water, and the result was at the completion of the test (which lasted one hour) that on an average the distance attained by Shand, Mason and Co.'s engine was 145ft.—maximum, 149ft.; Merryweather and Son's engine was 98ft. —maximum, 112ft.; the average pressure of steam being, for Shand, Mason and Co.'s engine, 140lbs. per square inch—maximum, 150lb.; Merryweather and Son's engine, 97lbs. per square inch—maximum, 140lbs.; and the average water pressure for Shand, Mason and Co.'s engine was 115lbs. per square inch—maximum, 125lbs.; Merryweather and Son's engine was 96lb. per square inch—maximum, 120lbs. The engines were then put under test No. 3, which was to show their action with the branch pipes set vertical—(in this trial Merryweather and Son, with consent of Shand, Mason and Co., altered their nozzle from No. 21 to No. 20—small—equal to 1 7-32in.) with the following results:—Shand, Mason and Co.'s engine showed an average excess of height in the stream of water thrown over that thrown by Merryweather and Son's engine of 12ft.—the maximum being 15ft. The average steam pressure during this trial, (which lasted twenty minutes) being, for Shand, Mason and Co.'s engine, 149lbs. per square inch—maximum, 160lbs.; Merryweather and Son's engine, 110lbs. per square inch—maximum, 140lbs. Tests 4, 5, and 6 were then combined by general consent, and arrangements made for each engine to throw two jets of water through the Glasgow Fire Brigade hose (four lengths to each jet), fitted with bayonet couplings and joints, the nozzles being all of a uniform size, viz., ⅞in. diameter. The engines were then started simultaneously at 3 hours, 13 minutes; but the water pressure was so great that at 3 hours 15 minutes (2 minutes after starting), one of the hose attached to Shand, Mason and Co.'s engine burst, and in 15 seconds thereafter Merryweather and Son's engine also burst a hose, thus bringing this trial to a close in 2 minutes 15 seconds. After these tests had been concluded, we subjected the engines to various tests, as to speed, power, &c., and also allowed the competitors to show the capabilities of their engines to the utmost. This being done, the trials were brought to a conclusion; and we have now to report as follows:—Boilers and fuel—Both boilers are strong and well constructed, admirably adapted for rapid steam raising and maintaining steam at a high pressure, as the foregoing figures indicate. The coal consumed during the trials was, for Shand, Mason and Co.'s engine, 8 cwt.; Merryweather and Son's engine, 9 cwt. 0 qrs. 21bs. We may mention, however, that Shand, Mason and Co.'s had a stoppage for 1 min. 10 secs., which will somewhat reduce the apparent advantage over Merryweather and Son's. As we do not deem it necessary to trouble you with mechanical details, we avoid entering into any description of the respective engines, but in passing may say that Merryweather and Son's has two direct-acting pumps, Shand Mason and Co.'s having three. This gives the latter the benefit of a more continuous stream of water and greater regularity in working; and whilst both engines are good specimens of engineering, we are inclined, in accordance with the results indicated in the former part of this report, to give, after due consideration, our decided preference to Messrs. Shand, Mason and Co.'s engine."

The committee having considered the foregoing report, agreed to express approval of it, and to recommend that the engine of Shand, Mason, and Co. be purchased, after a satisfactory test of the boiler had been made.

THE INSTITUTION OF CIVIL ENGINEERS.

ON THE CONDITIONS AND THE LIMITS WHICH GOVERN THE PROPORTIONS OF ROTARY FANS.

By Mr. Robert Briggs, of Philadelphia, U.S.

The author stated that, by the theoretical investigations of Redtenbacher aud Rittinger, of M.M. Combes and Péclet, and of Mr. Appold, as well as by the recent practice of constructors of fans, the conditions and the limits that would be attempted to be established were more or less acknowledged.

A rotary fan might be said to consist, primarily, of a certain number of tubular passages, which were rotated about a lineal axis at right angles to the direction of the passages, whereby a given volume of air, impelled either by centrifugal force, or by the shape given to the tubular passages radially, was moved at a determined pressure. In other words, it might be conceived that a shaft revolved, upon which was placed a disc or set or arms, to which disc or arms some blades or vaues were attached, the zone of blades or vanes having sides or a casing, either in close proximity to the edges of the blades or vaues, or attached to and made to revolve with them: and theu the area enclosed between auy two blades or vanes and the sides or casing might be considered as a tubular passage, with an entrance at the centre of the fan and au exit at the periphery. The conclusions drawn by M. Péclet, from a course of reasoning based upon the tube example, were at variance with the experience of the author of the paper, aud might be extended, first, to a tube closed at the axial end and open at the periphery, when the partial vacuum would correspond to that due from the velocity of a body of the density of the atmosphere at the time, falling with the velocity at which the extremity moved; and, secondly, to a tube closed at both ends, when, whatever might be the density of the enclosed atmosphere, the pressure on the axial end would be less than that on the outer end by that due from the velocity of a body of the density of the enclosed air, falling with the velocity at which the extremity moved. Hence, whatever the shape of the vanes of a fan, its maximum pressure or suction iuvolved no delivery whatever; and if the fan were so proportioued that no regurgitations took place as the blades passed any point in the case, such a fan would consume no power when it was closed, either at the inlet or the outlet, or both, for it was performing no work. The condition was that of a fly-wheel at a uniform velocity, or a ball-goveruor with the balls spread to runuing positiou. Now the pressure attainahle by any rotary fan was an exceedingly low one, when considered in pounds per square inch; thus a column of water of 14 inches or 16 inches gave velocities dangerously near the strength of materials of which fans were constructed, in resisting centrifugal force, and a column of water of 7 iuches or 8 inches was attainable only by very high speeds. In fact, a pressure or suction of 3 inches or 4 inches was nearly as large as could be ecouomically attained, in delivering a quantity of air, when the friction of machinery at high velocities, the want of adhesion of belts, and certain other considerations of the frictiou of air on the vanes, were accounted for. Thus, the largest differences of pressure were less thau the ordinary atmospheric disturbances, as indicated by the barometer.

It was possible to construct a series of fans, following from one to the other, and to iucrease the pressure by repeated efforts; and this method was applicable to many purposes where the volumes to be moved were beyond the scope of a pump, and the pressure was relatively low to that obtained from pumps. So far as volume was concerued, a very small fan represented the largest blowing engines at blast furnaces. This limit of efficieucy, as regarded pressure, was the first limit of a rotary fan.

Since the terms, pressure on the one hand and suction on the other, were interchangeable, and did not vary so much as the atmosphere, it happened that the suction fan of the most economic proportions was identical with the blast fan best adapted for the performance of duty. This condition was regarded as of the highest importance in simplyfying the study of the fan questiou.

But the propositions, that the fan of suction was that of blast, and that suction and pressure were interchangeable, implied and carried with them the conclusion, that the actiou derived from the shape of the blade should be the same on the entering air as on that leaving the fan. This condition, however, was only iucident to oue particular shape of blade, that was, oue where the angle of the blade at any point was constant with any radial line at that point—in other words, was a logarithmic spiral. This angle might be from 0° to 90°, that was, from a straight line to the impossible case of a series of concentric circles, but the shape would insure each part of the blade giving an impulse to the air in contact with it proportionate to the velocity of that point round the axis. Taking this form of blade, aud supposing the air to be impelled with velocities proportiouate to the radial distances from the axis, then the area of each concentric ring should diminish as the length of the radii increased. The calculations and the formula for determining the section of the coue of the fan from the mouth to the periphery were theu given.

At the entrance of a fan, the direction of the currents of air was at right angles with the plane of rotation; and, in the case of the ordinary fan, taking in air at both sides, the two entering currents were directly opposed to each other. In the centre between the currents there might be inserted a conoid, so shaped that each particle of air should preserve its uniform velocity, and be gradually diverted into the directiou desired. The couoidal mouth of the fan should be of such a shape as to give a constant area to the passage formed between a newel, or corner round the mouth, and the surface of the conoid. The calculations and the formula demonstrating the outline of the couoid were then given. With this sectiou of mouth, and that previously described for the zone of the blades (supposing them to be a logarithmic spiral), aud with the supply of air which the velocity of the tips of the blades demanded, the air would enter with the least resistance until it reached the blades, would fill the fan whilst it was accelerated, and be discharged with maximum effect.

In a fan 10 feet in diameter, and only 2 feet in width at the circumference, and having 62·83 square feet of area of discharge, the openings on both sides should be 7·42 feet in diameter and 3·63 feet wide at the inner edge of the zone of blade. This left only 1·22 foot for the width of the zone of blades from the opening to the periphery. But the zoue of blades was made as wide as 2 feet at the disc, so that the average width of the zone was 1·65ft. Attention was directed to this departure from the usual proportions, to indicate the advautage of more thau the ordinary number of blades, and the discussiou would fail to be understood unless the opportunity, if not the necessity, of so doing were demonstrated.

After it was ascertaiued that any particular form and number of blades would produce the highest useful effect, at the pressure related to the velocity of the periphery of the fan, if it was desirable to have a higher pressure, it would be best obtained by giving a greater velocity to the fau, and not by altering the shape of the blades to a form of less efficiency; unless when the desired pressure approached the strength of the parts of the fan to resist centrifugal force, and it was advisable not to employ a fan of repeated effort, when the blades became beyoud question radial and the useful effect was secondary.

In the years 1856 and 1857, the author, who was then employed as one of the principal assistants upon the works of the United States Capitol Extension and the Washington Aqueduct, under the engineering charge of Captain (now Major-General) M. C. Meigs, had delegated to him the investigation of what form of fans should be employed in ventilating the buildings of the Capitol. A series of experiments with models, based on the reasoning adduced in the paper, gave as the best shape or curvature to the blades, that which had been indicated, a logarithmic spiral of 45°, and showed a loss of mechanical effect when, within the zone of blades, the number of blades employed exceeded that which allowed the heel or inner edge of one blade to much more than pass the point or outer edge of the next in a radial direction, or in the direction in which the current of air, when the maximum discharge was occurring, passed.

The same rule would hold good with fans having radial blades; for as then the direction of the current was at angle of 45° to the radius vector, the overlapping of the opposite ends of the two contiguous blades in relation to the current would take place in the same way. Taking a fan of 10 feet in diameter of the proportions assumed, where the zoue of blades had been stated to be 1·65 foot average width, about sixteeu blades would be required for a fan with blades at angle of 45°, and about twenty-four for the same fan with radial blades. The fan here described was narrow, with a large opening on both sides, and numerous blades, as compared with the usual practice; but it possessed the merit of being the smallest in external diameter, of having the largest capacity, and the least surface friction compatible with the contact of the air with the blades.

It was not pretended that a fan of the usual proportions, with the diameter three or four times the opeuing at the side or mouth, and the relative width much greater than had been assumed, was radially inefficient; nor that even in such a case, if the number of blades were limited to four, six, or eight, or where the case was composed of flat plates, there was a total loss of efficiency. So far as the extremity of the blades merely rotated a mass of air which was not passed forward, no power was consumed, upon the principle of the tube closed at the inner end. The air could only be delivered so fast as, by the action of some part of the blade of a fan thus constructed, it could be induced to enter at the restricted openings at the side. But the rolling of compressed air, intercepted by the outer ends of the blades and the friction upon the enlarged surfaces, must consume more or less power.

A table was next given of the proportions of fans with less blades than had been assumed, showing that eight blades of 45°, or twelve radial ones, were the least number desirable, as a fau 10 feet in diameter then became only 0·62 foot in width at the tips of the blades.

The reasoning was adduced on which the calculations of quantities and pressures were based. It was urged that when all the resistances of the fans were considered, the unrestricted discharge with unrestricted supply would occur at one-half the velocity of the tips of the blades and the pressure to correspond, while the quantity would equal a discharge at that velocity through eighteenths the area of the fans at the tips.

Up to this point it had been possible to demonstrate by reasoning, or with the modification of some co-efficients, the proportions euumerated. But there were no accurately determined figures to show the relationship between the quantities of air discharged and the increased resistances. The instances in use, although numerous, about a hundred in fact, had been restricted to cases where ducts were employed, some or all of which had been closed off at one time, no regularity of working having been adopted; nor were there any experiments to show the variations of pressure, when the quantities were increased or diminished. The author had assumed, in giving the performance of fans, that double the unrestricted pressure could be got with half the quantity of air. This relationship seemed to be warranted by many results, where the quantity of air had been measured by au anemometer, and the pressure registered by a gauge simultaneously; but the law of the relatiou of variation of quantity with pressure to this limit, or further limits, had not been determined. The ultimate pressure attainable for the discharge was four times, less 10 per cent., or 3·6 times the pressure of unrestricted discharge. The assumption that half the quantity would be delivered under double the pressure involved the passage of the curreut of air iu a radial direction through the blade at half its unrestricted velocity, and the rotation of the air with the fan at such a rate that its centrifugal force should equal the double pressure assumed.

It should be borue in mind that this double pressure followed when the air was impelled tangentially at 0·707 the velocity of the tips of the blades, and that this was the speed which would be given to the current outwards, when there was an infinite number of frictionless blades, with the logarithmic curve of 45°. That there would be discharged quantities of air up to the limit of pressure was certain, but the economic effect of the fan fell off rapidly, as the blades were only moved at high velocities through a bath of air without producing proportionate results. With these estimates of unrestricted discharge and pressure, and the modification of a a certain pressure up to double the unrestricted pressure, the limits of fans of proper proportions were brought to definite conclusions.

The general dimensions and description next followed of a 10-feet fan. It was stated that this construction of fan was also adapted to the ventilation of public buildings and to the supply of air for puddling and heating furnaces, for all of which purposes they were in common use in the United States.

In conclusion, tables were given of the presumed duty of fans for different uses, admitting of practical application to many purposes; including the capacities of a 10-feet fan, with an unrestricted discharge, and a discharge restricted to half the quantitity, of fans to be used for the ventilation of public buildings or mines, for the supply of air under grates of puddling or heating furnaces, and to tuyeres, or cupolas, smiths' forges, hollow furnaces, &c. In each case the tables embraced the following particulars:—The number of revolutions and the quantity of air delivered per minute, the pressure, the proper dimensions of the pulleys, and the horse power required for the several conditions.

ON THE DRESSING OF LEAD ORES.

By Mr. T. Sopwith, jun., M. Inst. C.E.

This communication was limited to a description of some works the author had had occasion recently to establish in Spain, for the dressing of lead ores, as a general account of the present state of such operations in England could not be satisfactorily given in a single paper. Moreover, as regarded this branch of mechanical engineering, Germany was in advance of England. By dressing was to be understood the art of obtaining from the raw material extracted from the mine, called bouse or mine stuff, the pure ore it contained, to the rejection of the impurities with which it was associated. Bouse might be said to yield, in an ordinary way, from 5 per cent. to 25 per cent. of galena, which when pure had a specific gravity of 7·75, and produced 86 per cent. of metallic lead. The lead ores of commerce were usually dressed to a tenour of from 74 per cent. to 78 per cent., though argentiferous ores were frequently delivered with a lower per centage. All galena was mixed with silver; but the term argentiferous was only applied to that in which there was upwards of 12 oz. of silver per ton. In dressing, the principle applied was that of separating the lead ores by means of their readier gravitation. This operation was easy or difficult according as the accompanying impurities were of greater or less specific gravity.

At the works referred to, about 350 tons of lead ore were prepared per month. There were two dressing floors, the higher and the lower. On the former manual labour was principally employed. On the lower floor the stuff was treated which required to be passed through the crushing mill; and it was more particularly this machinery and method that it was the purpose of this paper to describe. On the higher floors from 200 to 220 tons per month were prepared, or two-thirds of the entire quantity. Two systems of paying the miners were adopted in mineral mines; one, by "tribute" or "bingtale," where the men were paid in proportion to the amount of clean ore the mine stuff excavated by them produced; the other, "tutwork" or "fathomtale," where they were paid by measurement. The adoption of the former system introduced complication, and more expense in the dressing operations than the latter.

The author, in describing the various machines, and the quantities of work they could deal with, fixed as a standard the richness of mine stuff treated at about 12 per cent. (by weight), equal to work which would be known in the North of England as producing 2½ bings per shift.*

The washing operations commenced by turning a stream of water into the "teams" containing the "bouse," which was raked out by a man on to a grate, and there hand-picked. The author used two grates; the higher one with spaces of 1in., and the lower one of ½in., in preference to the one grate with spaces ⅝in. wide as usually employed. The stuff passed through the second grate into a stirring trunk, where a partial separation of the coarser particles from sludge and slime was effected. The coarser particles were of a size convenient for hotching, and the common hotching tub could treat from 8 tons to 15 tons of stuff per day. Between the waste, which was wheeled away, and the pure ore, there was an intermediate layer of what was called "chatts," consisting of particles mixed with ore which could not be separated without further sub-division. This was effected by means of a crushing mill. In England from 25 tons to 30 tons was a fair day's work to pass over one grate. The author found, by the use of two grates, that 40 tons could be passed, without any increase of labour, at a cost of about 2s. 6d. per ton of clean ore produced.

The ore which passed through the coarse wire bottom of the hotching sieve, accumulated at the bottom of the tub, and was called "smiddum." This was rendered fit for market by further preparation in the plain buddle. The sludge deposited in the trunks attached to each grate was prepared in a round buddle. A separation having first been made of hard lumps, small stones, or chips of wood, &c., the sludge was delivered at the centre of the buddle accompanied with water. The bottom being inclined outwards about 1 in 10, the particles were carried by the water in that direction; the heaviest and richest being deposited nearest the centre. The buddle described was larger in diameter, and treated nearly four times more stuff, than that usually employed. The water on leaving the sludge trunk carried with it a certain amount of slime, which was deposited in pits, and was subsequently treated in a machine called a Brunton's cloth, the action of which was described, as also of the dolly tub, by which the slimes, after being concentrated in the Brunton's machine to about 45 per cent., were further enriched to about 70 per cent., and so delivered for sale. The crushing mill in common use in England was described, and the inconvenience attached to it, as compared with the simpler form used in Germany, was pointed out. In the apparatus that had been referred to, it was probable that about 80 per cent. of the lead ore produced in England was prepared.

On the lower, or crushing mill, floors, which the author had erected, some attempt had been made to secure continuity of action, by the use of self-acting machinery, wherever it was possible; though from the circumstance of Spanish labourers being employed, who were totally unaccustomed to the use of machinery it was necessary that the machines should be of the simplest kind. The stuff which required crushing was conveyed in waggons to the lower floors, being first broken to a size which would pass through a 5-inch ring. This was effected by manual labour, in preference to a stone-breaking machine, as the former allowed of a separation of a small quantity of pure ore, and of a large quantity of waste, which would afford unnecessary work for the crushing mill. The stuff, after being emptied from the waggons in the hopper of the crushing mill, was passed through the rollers, and, when crushed, was elevated by a Jacob's Ladder, and delivered into a classifying trommel, composed of two shells, an outer one of perforated iron plates with holes of 1½ millimetre in diameter, and an inner one with holes of 10 millimetres in diameter. The crushed material was delivered in the inside of the trommel at one end, and passed onwards, the trommel being inclined. All the sludge and slime were got rid of through the outer shell, the inner shell retaining and delivering apart any particles over 10 millimetres in diameter. These were returned to the crushing mill, to be again passed through the rollers, and the particles, ranging in size between 1½ millimetre and 10 millimetres, were delivered at the further end of the trommel, and passed on to a second, or sizing, trommel, composed of one shell only, and were then sub-divided into four sizes, viz., 2½, 5, 7½, and 10 millimetres, each size being treated in a separate hotching tub. For the operation of hotching, the convenience of having all the particles treated of one, or nearly of one, size, was obvious; and in some cases of refractory ores it was a necessity. The hotching machines employed were entirely self-acting, and continuous in action; a fast and a loose pulley being attached to each machine. Contrary to the form adopted in England, the sieve was stationary, the water being put in motion by means of a loosely fitting piston. The stuff was delivered into a small hopper, and travelled the length of the sieve, a distance of 28 inches, by which time a perfect separation was effected. It had been found advantageous to increase the length of the stroke, and the number of strokes per minute, for the larger sizes. By an ingenious movement, a quick down stroke and a slow return stroke had been given to the piston. The crushing mill was more compact than the form used in England, the rollers being kept in contact by the compression of india rubber buffers, in place of a long lever, with a heavy weight attached. The sludge, which passed through the holes of 1½ millimetre in diameter, in the first, or classifying trommel, was delivered into a separator,—an iron cylinder about 2½ ft. high,—where it met a stream of water of sufficient strength to carry the smallest and lightest particles upwards, and deliver them into a launder, whence they were conveyed, by the water, to the sludge trunks and slime pits, and were subsequently treated in round buddles and in Brunton's cloth. The coarser particles were prepared by manual labour, in a common trunk or tie.

The amount of work crushed and prepared on the lower floors was about 55 tons per day of ten hours. The actual cost in Spain was 21s. 2d., but the equivalent of labour would be performed in English mining districts for 13s., the latter sum being at the rate of 2·83 pence per ton of raw material treated, or 2s. per ton of clean ore produced. If, however, self-feeding apparatus was introduced to supply the hotching machines, which could easily be done, the latter cost might be reduced to 2·07 pence and 1s. 5¾d. respectively. The cost of preparing similar work in England, with machine crushers and machine hotchers, was, the author believed, about 2s. 6d. per ton of clean ore. The whole of this machinery was driven by a 10 H.P. portable engine, supplied by Messrs. Ransomes, Sims, and Head. The cost of erection of the crushing mill floors complete, including the engine, was about £1,500. The same arrangement in England would have cost about £1,200. Most of the machinery was supplied by Messrs. Sievers and Co., of Kalk, near Cologne. No separate crushing mill for the preparation of "chatts" had been erected, as when the "chatts" had been allowed to accumulate, the present machinery could be adapted for their treatment in an hour or two, advantage being taken of a time when new rollers had been put in.

The author observed that whereas, in England, the machinery employed in dressing operations was for the most part made at the mine with the ordinary staff, in Germany there were manufactories giving employment to four hundred hands, dedicated almost exclusively to the construction of dressing machinery; and it was not surprising to find, in the machines issued from them, better proportions, greater elegance, and more efficiency and durability than those used in the mines in this country.

The machinery described in this paper had been in use for two years, and, having given good results in Spain, no difficulty need be feared in its application elsewhere.

* A bing was 8 cwts. A shift was eight waggons, carrying about 1 ton each.

THE ST. PANCRAS STATION AND ROOF, MIDLAND RAILWAY.

By Mr. W. H. Barlow, F.R.S., M. Inst. C.E.

After tracing the gradual growth of the Midland Railway from a local line to that of a great system, having access to numerous large and important towns, to the commercial centres of Yorkshire and Lancashire, and to the rich mineral districts of Derbyshire and Leicestershire, reference was made to the extension from Bedford to London, with its terminus in the parish of St. Pancras, where the company had previously formed a goods' yard, and in the neighbourhood of which an estate was purchased, adjoining the Euston-road, as a site for the new station. The approach to the land so acquired was crossed by the Regent's Canal, at a distance of about 45 chains north of the Euston-road; and in order to secure good gradients and suitable levels for stations at Camden-road, Kentish Town, and Haverstock Hill, the main passenger line was carried over the canal. It resulted from this arrangement, that the level of the St. Pancras station was from 12ft. to 17ft. higher than that of the adjacent streets. On the other hand, a branch for effecting a junction with the Metropolitan Railway was passed under the canal, as well as, on a curve obliquely from the western to the eastern side, under a considerable length of the main line and its works, including the passenger station. In consequence of the height of the rails above the ground level, a large area was available beneath the station, which it was determined to utilise for Burton beer traffic; communication between the two levels being effected by means of hydraulic lifts. To economise this space as much as possible, columns and girders were adopted, instead of brick piers and arches; the distances between the columns being the same as those of the warehouses, which were expressly arranged for the beer traffic.

In considering the question as to the roofing of the station, it became obvious that, if intermediate columns were employed, they must be carried down through the lower floor, be about 60ft in length, and of much larger diameter than the rest of the columns under the station. This would have necessitated the employment of different patterns in the girders, cross-girders, and in the plating of the lower floor, and have increased the price per ton for that portion of the iron work, besides interfering with the economical distribution of the space. Moreover, these columns must have carried large areas of roofing in addition to the flooring, adding a greatly increased weight to be supported by the foundations, which must have been enlarged accordingly; and as some of them would necessarily have been placed on the tunnel of the branch under the station, special means, involving increased expense, would have been required to carry the imposed weight at those places. On the other hand, it was seen that the floor girders across the station formed a ready-made tie sufficient for an arched roof crossing the station in one span; all that was required to obtain a roof of this construction being the arch or upper member of the truss, of which the floor girders would form the lower member. In iron roofs as usually constructed, the depth of the principal was about one-fifth of the span; but in this case, by adopting one arch extending across the station, the height from the tie beneath the rails to the crown of the arch became the effective depth of the truss; and this height being about two-fifths of the span, all the horizontal strains arising from the dead weight of the roof, its covering, and accumulation of snow, &c., would be about the same in the arch of 240ft. span, with an effective depth of truss of 100ft., as in an ordinary truss of 120ft. span with a depth of 24ft. Excepting, therefore, such additions as might be necessary for retaining the form and figure of the arch, the actual sectional area at the crown, and for about two-thirds of the entire arch, did not require to be greater than in an ordinary truss of 120ft. span. There were several other advantages belonging to the arch, one being that as the weight of the roof was carried at the floor line, there was no necessity to make the side walls so thick as usual, for not only was the weight on the tops of the walls avoided, but also the racking motion from the expansion and contraction of an ordinary roof, which, though it might be mitigated, was not prevented by the use of roller-frames at the feet of the principals, and appliances of a like nature. It was also apparent, that the arch might be made of riveted plate ironwork like that of an ordinary railway bridge, and that the expense attending the use of forged and wrought work as in ordinary roofs would be avoided, including the screw cutting, gibs and cotters, welding, and similar costly workmanship. Again, as to the question of the expansion and contraction of the arched roof, the ties being beneath the ballast the temperature would vary so little, that no provision would be necessary; and for the arched part of the roof, which would alone be subject to appreciable change, the only effect would be a slight rise or fall in the crown.

All these circumstances tending to favour the idea of a single arch across the station, it remained to be decided what depth and form of rib, and what additional material would be required. The results arrived at, partly by calculation and partly by experiment, were—first, that the depth of the rib must be sufficient to contain all the lines of pressure generated by the dead load, by snow, and by the pressure of the wind; secondly, that the sectional area of the metal should be sufficient to sustain the whole stress without producing a strain on the iron exceeding $3\frac{1}{2}$ tons per square inch; and thirdly, that the arch should be riveted together with proper joint-plates throughout, so as to give it the advantages of complete continuity.

The general arrangement of the station followed the type suggested by the stations at Cannon-street, Charing Cross, and Victoria, in so far as the arrival trains were brought in on both sides of a carriage road in the interior; but it differed from them in this respect, that the main booking offices were on one side instead of at the end of the platforms. There were, however, other booking offices at the end, which might, if necessary, be use for a central platform.

The lower floor contained seven hundred and twenty cast-iron columns set with stone bases on brick piers. There were forty-nine rows of principal girders across the station, and fifteen similar girders running longitudinally. These carried intermediate girders, and the whole was covered with Mallet's buckle-plates. The strength of the girders and plating was sufficient to carry locomotives all over the floor, of which the cost of the iron work was £57,000, or rather more than £3 0s. 6d. per square yard, the entire area measured within the walls being 18,822 square yards.

The main ribs or principals were made of channel-iron and of plate-iron, and were 6ft. in depth, or one-fortieth of the clear span. The rib between the walls was of open work, but the extremities of the principals in the walls were of solid plates. The total weight of each rib was 54 tons, 16 cwt., and its cost was £1,132 4s. The width between the walls was 245ft. 6in., and the distance from centre to centre of the ribs was 29ft. 4in. The arch was slightly pointed at the crown, as this form apparently possessed some advantages in resisting the lateral action of wind, while it improved the architectural effect. The radius of curvature was diminished at the haunches, to give increased head room near the walls. The glazing was ridge and furrow, ventilation being obtained along the whole length of each ridge.

The erection of the roof was effected by two large timber stages, each made in three divisions, so that each part of either stage could be moved separately. The process of erecting was as follows: The two lower portions, or the feet of the ribs, were first set temporarily in position, the brickwork underneath them being kept about 3ft. below its intended height. The feet were then accurately adjusted, and were riveted to the ends of the floor girders; after which the brickwork was carried up in blue Staffordshire bricks set in Portland cement, and the whole secured to the underside of the ironwork. The open work of the main ribs was commenced from the extremities on each side, in divisions of about 18ft. in length, and these were placed temporarily together, supported by the staging, until all the pieces were in position. The whole was then adjusted for line and level, and riveted together with the purlins and other ironwork. The greatest depression of any rib when the centre was struck was only $\frac{1}{4}$ of an inch, while the average was of $\frac{3}{16}$ an inch.

In arranging for the strength of the roof, as it was required that the arch should be capable of maintaining its own weight, without any intermediate connections with the tie, it was considered expedient to adopt a low rate of pressure upon the metal, with a large assumed weight acting in addition to the weight of the principal. With this view, the arch was designed so as to be capable of bearing an assumed load of 70lbs. per square foot measured on plan, in addition to the weight of the principals, with a stress on the metal not exceeding $3\frac{1}{2}$ tons per square inch; or, what amounted to about the same thing, a load of 56lbs. per square foot, with a stress of 3 tons per square inch. The assumed weight of 70lbs. per square foot on the surface carried by the arched portions of the rib, viz., 7,040 square feet, amounted to 220 tons, and adding to this the weight of the open part of each arch between the springings, or 35 tons, the total load became 255 tons. The line of pressure formed an angle of 55° with the horizontal at the springing, and therefore the pressures were 155 tons at the springing and 89 tons at the crown. The sectional area of the upper flange of the rib was 23 square inches and that of the lower flange of the rib also 23 square inches, so that the stress on the metal with the assumed weight of 70lbs. per square foot was 3·37 tons per square inch at the springing and 1·94 ton per square inch at the crown.

The cost of the roof, as it stood in the finally settled accounts, excluding the screens, was £53,483. The north screen and gable had cost £7,375, while a second screen and gable for the southern end, so as to separate the passenger station from the hotel buildings, had cost £8,507. As the area within the walls measured on plan was 169,400 square feet, it followed that the cost per square of 100ft. was, for the roof, excluding the screens, £31 11s., for the north screen £4 7s., and for the extra rib and south screen £5.

The brickwork of the substructure of the station, and the whole of the works of the upper and lower lines of railway for a distance of $\frac{3}{4}$ of a mile northwards, were let to the Messrs. Waring, and had been carried out under the superintendence of the author's principal assistant, Mr. Campion; while the ironwork of the bridges and of the lower floor of the station was in charge of his assistant, Mr. Grier. For the details of the roof the author was in a great degree indebted to Mr. Ordish. The Butterley Company were the contractors for the roofing and for the lower floor, Mr. (now Sir) G. J. N. Alleyne being their manager, and Mr. Clark their foreman on the works. The Midland Company had secured the services of Mr. Gilbert Scott, R.A., to carry out the station buildings and hotel above the level of the foundations.

In conclusion the author remarked, that the general question of the cost of roofing, considered purely from a structural point of view, was a simple problem. The great governing element was the description of covering, as it affected both the cost and the weight. Light corrugated iron was not only cheaper than boarding and slating, but it was not much more than half the weight, and therefore required less strength in the principals or trusses. With the same description of covering and the same weight of purlins, the weight of material in the trusses varied nearly as the squares of the spans; accordingly, if estimated at per square of roofing, it varied directly as the spans. With the ordinary truss, the distances between the principals being about 30ft., and the covering being of boarding, slating, and glass, the weight of metal required in the principals could be expressed approximately, in tons per square of roofing, by dividing the span in feet by 320. A reduction of one-half in the weight of the covering did not, however, admit of the weight of the principals being reduced more than about one-third. But these rules, though fairly borne out in practice, were not sufficiently accurate for very large spans. In that case, and also for the comparison of the structural values of one class of truss with another, it was best to have recourse to the limiting spans; that was to say, supposing a given structure, which was capable of carrying a given load with a given strain upon the metal, to be enlarged equally in all its dimensions, then, inasmuch as the sectional area of the metal on which the strength depended increased as the square of the span, while the weight of the structure increased as the cube, it followed that there was a span at which the weight of the structure alone, without any load, would generate the given strain on the metal. The idea of treating the relative values of structures by means of their limiting spans was due to Professor Rankine. It afforded a ready method of obtaining approximately the weight of an intended structure before the drawings for the work were commenced, and thus enabled any undue waste, either in the fastenings and connections or otherwise, to be readily detected.

At the meeting of this society on Tuesday, the 5th ult., Mr. Charles B. Vignoles, F.R.S., President, in the chair, nineteen candidates were balloted for and duly elected, including four Members, viz.: Messrs. John Bailey, Dublin; William Elsdon, Melbourne, Victoria; Alexander Kendall Mackinnon, Director General of Public Works, Monte Video; and Thomas Fothergill M'Nay, Westminster. Fifteen gentlemen were elected Associates, viz.: Messrs. John Austie, B.A., Westminster; John Collins Boys, Granville-place; Thomas Cargill, Beaufort-buildings; James Robert France, late Acting Engineer of the Submarine Telegraph Company; Henry Gaerth, Westbourne-park-terrace; Lieut. Geo. E. Grover, R.E., Woolwich; David Gravell, Stud. Inst. C.E., Contractor's Staff of the Sucazawa, Jassy, Roman, Bottuschany Railways in Moldavia; F. J. Princes-street, Commercial-road; Joseph Kincaird, B.A., St. James's-street; Henry Ernest Milner, late Engineering Staff, Windsor and Annapolis Railway; Thomas Newbigging, Manager of the Rossendale Union Gas Works, Bacup; Ernest Bengough Ricketts, Engineer's Office, Trinity House; Frederick Warburton Stent, Westminster; Edward John Tatam, Moulton, near Spalding; and Clarence Edward Trotter, Stud. Inst. C.E., Westminster.

A report was brought up from the Council stating that, under the provisions of Sect. IV. of the Bye-laws, the following candidates had been admitted Students of the Institution since the last announcement:—James Hall Blake, Massey Bromley, B.A., John Henry Eykyn, Alfred Fyson, James Gilchrist Gilchrist, James Henry Greaves, Hilin William O'Neale Neale, William Patten, Robert Pickwell, and Charles Graham Smith.

INSTITUTION OF NAVAL ARCHITECTS.

The first meeting of the eleventh annual session of the Institution was held in the Lecture Theatre of the South Kensington Museum on the 6th ult., the President, Sir John Pakington, Bart., in the chair.

REPORT OF COUNCIL, APRIL, 1870.

It will be unnecessary for the council, on the present occasion, to address to the members and associates of the institution more than a very few words by way of report; the internal affairs of the institution having progressed satisfactorily.

The council are glad to be able to state that the Lords of the Admiralty have been pleased to renew their grant of £250. As this grant was actually paid in the month of December, 1869, it necessarily appears in the balance sheet for the past year, although not belonging to that year's ordinary income.

The privilege of becoming members of the institution has been offered by the council to the following distinguished marine engineers, under the authority of the last paragraph in the report of the council for 1869, which was adopted by the meeting:—Marine Engineers: Edward R. Alfrey, Esq.; Alfred Blyth, Esq.; William Denny, Esq.; Sir William Fairbairn, Bart.; Joshua Field, Esq.; Telford Field, Esq.: J. Henderson, Esq.; John Key, Esq.; J. G. Laurie, Esq.; Hugh Morton, Esq.; John Penn, Esq.; John Ravenhill, Esq.; George Banks Rennie, Esq.; George Robert Stephenson, Esq.; John Trickett, Esq.

An arrangement has been entered into with the committee of the Canoe Club, upon terms advantageous to both institutions, by which the committee of that club is enabled to hold periodical meetings in the rooms of the institution, at such hours as not to interfere with its business. By the kind permission of the Lords of the Committee of Council on Education this report is presented to you in the Lecture Theatre of the South Kensington Museum. You are invited to inspect the premises of the Royal School of Naval Architecture and the magnificent collection of models in the Naval Gallery. The council are informed that the alterations which have been made in the course of instruction given at the Royal School of Naval Architecture and Marine Engineering appear to promise satisfactory results. Changes of this nature, however, cannot be expected to produce immediate fruit, and the council, therefore, await with much interest the report upon the examination of the school at the end of the present session, the first occasion of the conclusion of the four years' course. The council observe with regret that the number of private students has decreased.

THE PRESIDENT'S ADDRESS.

The President said: I now rise to perform the duty of offering a few observations of such a nature as may appear appropriate to the occasion upon which we meet. It is a duty which has devolved upon me every year since I have had the honour of holding the office of your president, an office which I assure you I value most highly. But I have always felt that, although the address of the president is a form which is always observed, and a form that is not without its value and utility, still, considering the nature of the duties for which we assemble, it is always desirable that the observations of the President should be compressed within reasonable, if not narrow limits, in order that undue intrusion may not be made upon those duties of the day which, in my opinion, are more important. Gentlemen, I cannot refrain from expressing the great satisfaction and pleasure with which I meet you again at the commencement of another annual session, and that under circumstances which, in two respects, are circumstances of novelty. And I think those two circumstances of novelty may fairly be regarded an indicating a state of growing prosperity and success on the part of this institution. The first circumstance of novelty to which I refer is the fact that now for the first time we assemble on Wednesday instead of on Thursday; that is, we assemble for a session of four days instead of only three. Another innovation, and I think it is one of a very interesting character, is that, for the first time, by the kind permission of the Committee of Council on Education, we are enabled to meet at South Kensington on the opening day, instead of assembling as heretofore at the Society of Arts. The fact of our assembling here gives us a double advantage; one is, that we assemble close to that beautiful, interesting, and I may say perfect collection of naval models which are now brought together in this building, and open to public view, instead of being stowed away as they were for a vast number of years in the cellars of Somerset House. Here they are brought together and arranged in a manner that enables all who take an interest in these matters of national importance to come and see them. And, of course, such an assembly as I have the honour to address would peculiarly delight in looking at that interesting collection of models. Another advantage which arises from our assembling here is that we are close to the School of Naval Architects, to which I think I may refer as almost a child of this institution. It is an establishment which we all regard as one of great national interest, and great prospective national advantage; and assembling here we are enabled to examine personally the whole of the arrangements of that most useful institution. Before quitting the subject of that institution I may, with perfect safety, say that it is still performing its useful function, and is likely to bestow upon the country those advantages which we anticipated from its establishment. You have heard a passage read from the report to the effect that the number of private students in the school has somewhat diminished. But I am far from inferring any serious diminution of usefulness in the institution from this fact. We should rather regard it as one of those cases of fluctuation in numbers which is unavoidable in almost every establishment of the kind. Gentlemen, not wishing to detain you any longer than it is really my duty to do, there are several subjects to which I might with propriety advert, but which upon this occasion I will pass over. There are, however, one or two topics on which I cannot be altogether silent. The first is not so much a subject of naval architecture as it is a subject most deeply concerning the interests of navigation. Whatever touches upon the interests of navigation must be deeply interesting to the great marine, whether warlike or mercantile, of this great empire. The subject to which I refer, and upon which I will venture to say a very few words, is what is called the "Rule of the Road." Upon the importance of that subject I need not dwell, and its importance has been forced upon the public mind very recently by circumstances which have appealed very strongly to public feeling. I refer to two most remarkable and painful instances of collision at sea—the collision which occurred in the eastern seas between the United States corvette the *Oneida* and the *Bombay*, one of the Peninsular and Oriental Company's vessels, and the painful occurrence which happened close upon our own shores a few days ago, the collision between the *Normandy*, a packet plying between Southampton and the Channel Islands, and the *Mary*. In both those melancholy cases great loss of life occurred. With regard to the first collision, it would be going beyond my duty, travelling into the ground which I could not with propriety touch, if I were to refer to the question which has arisen, and which will probably again excite the public mind, how far the captain of the *Bombay* by his conduct was responsible for the great loss of life that occurred. But every one will ask himself how was it that these two ships came into collision—how was it that they could not keep clear of each other at sea? Why has any question arisen for doubting the conduct of the captain of the *Bombay*? This inquiry of course leads to that all-important question connected with navigation—are the existing rules, known as "the rule of the road at sea," as good as they can be made for the protection of life and property at sea? Probably most of you will be of opinion that under the best and wisest regulations danger will still exist. But as far as I have been able to take counsel with those who are conversant with this subject, a strong impression exists that the existing laws upon this subject are not so well defined or so clear as they might be made. It therefore becomes a question whether or not for the public interest it is desirable that some inquiry should take place. Before I close the observations which I am addressing to you I shall have to touch upon another subject, if possible of even greater importance than that to which I am now referring, with the view of asking counsel from the competent judges here assembled, whether that is not also a subject upon which inquiry is needed. It might then become an important question whether this subject of "the rule of the road at sea" ought not to be included in such an inquiry in the event of such an inquiry being decided upon. Let me say this interesting subject is not limited to what we generally regard as "the rule of the road at sea." I think the dreadful collision which occurred the other day between the *Normandy* and the *Mary* touched upon another branch of this subject. It is not only how ships approaching each other are to be managed so as to avoid collision under ordinary circumstances, but in that melancholy case another question arises, whether the public safety does not require that some strict peremptory regulations should be adopted for the management of ships where thick fog prevails? There is no doubt that the melancholy loss of life which occurred in the *Normandy* was occasioned by thick fog. I do not desire to prejudge any case now under investigation, but I think enough has become known to the public to prevent our feeling any hesitation in saying that the main cause of the disaster was the fact of the ship going her full speed, or nearly her full speed, at a time of very thick fog. Possibly some persons may have observed that that melancholy loss of life became the subject of a question in the House of Commons a few days ago. I thought it my duty to follow up that question by inquiring whether the Board of Trade were or were not in possession of information as to whether the usual precautions of sounding gongs or bells had been resorted to. As far as I have yet learned the facts of the case, there appears to have been no such precautions taken; and it seems perfectly clear that the *Normandy* was going as nearly at full speed as her power allowed. Well, I say, here arises a question of the deepest interest, whether the time has not come for some public interference for the protection of that portion of her Majesty's subjects who are compelled to entrust themselves to the dangers of the deep; and whether captains of ships shall not be peremptorily required to moderate their speed at sea in a fog, and to resort to every precaution that can be adopted to insure the safety of human life. Gentlemen, having touched upon this subject, which I hope you will not think I have done improperly, there are two other subjects upon which I should have been glad to address you, but I find it is not necessary for me to occupy your time in doing so, because both of them are this very day made the subject of papers which will be read to you, and which, according to our usual custom, will afterwards become the subject of discussion. I allude to the Channel passage and to the Suez Canal. Not only the commercial interests of the country and the navigation of the seas, but the question of naval architecture is concerned in these two subjects. It will be for you, gentlemen, who are scientifically acquainted with the important subject of naval architecture to consider, and no doubt the papers that will be read will give you the opportunity of considering, how far the talent of our able naval architects should be brought to bear upon two most interesting questions. The first question is the best mode of constructing a ship ferry, which, after long deliberation, appears to be the favourite mode at present for expediting the transit across the Channel. The other question is one of hardly less interest; how we can best construct vessels able to carry large numbers of passengers and heavy cargoes from England to Alexandria, and yet be of such a draught of water as to be able to pass through the Suez Canal and continue their voyage to the East. These are subjects of deep interest; they not only call forth the skill of our naval architects, but they illustrate in a remarkable manner that rapid progress of scientific enterprise which is one of the distinguishing characteristics of the age in which we live, more especially of the latter half of the present century. There remains only one more subject on which I desire to touch. It is a subject which has been very much in my mind of late, and on which I desire to take counsel with you, with the view of deciding whether or not it is desirable that the Government should be pressed to institute and prosecute a scientific inquiry. The subject is, beyond all doubt, beset with a great number of difficulties; I allude to the question of the load draught of merchant ships at sea. Everyone has been deeply moved by what I am afraid we must now inevitably regard as the loss of the *City of Boston*, the most melancholy event of the kind that has occurred since the loss of the *President* many years ago. You will remember that at a period when hope was not altogether abandoned, an anonymous letter appeared in the public papers, purporting to come from Halifax in Nova Scotia, stating that when the *City of Boston* put to sea she was, from the large cargo stowed in her, from 18in. to 20in. below her proper draught. I dwell especially upon the fact that that was an anonymous letter. But on the other hand, I think those who read it will allow that there was nothing in the letter which conveyed to the mind any idea that it was written with other than honest and *bonâ fide* purposes, or that there was anything like ill-will towards the parties connected with the *City of Boston* which dictated that letter being written. I thought it my duty to put a question upon this subject in the House of Commons, and I asked whether the Board of Trade had received any information at all which tended to confirm the statements in that anonymous letter. The gentleman who, in the absence of Mr. Bright, now represents the Board of Trade in the House of Commons, very naturally and properly applied to that well-known and distinguished house, the Messrs. Inman, to whom the *City of Boston* belonged, for information. In the same spirit in which I have spoken with regard to the letter, I desire to speak with regard to the contradiction given by the Messrs. Inman. I should think myself wholly without justification if I were to say a word which could reflect upon that distinguished firm in any manner whatever. I accept entirely the assurance of the Messrs. Inman, and I believe they would not willingly risk the safety of their passengers by any improper proceeding. But public men who undertake a public duty must not look to the right or to the left in carrying out that duty; we are bound to regard only the safety of the public. Messrs. Inman, in their contradiction, which, on their behalf, was made in the House of Commons, entirely denied that any improper cargo had been stowed in the *City of Boston*. They only said that which it was right and proper in their position they should do. But we cannot forget that the Messrs. Inman speak from Liverpool, and that which was charged against the *City of Boston*, if true, occurred at Halifax. We cannot forget that the contradiction came from the agent of the Messrs. Inman at Halifax, the very person, who, if anything improper had been done, was exactly the person who would be responsible for that impropriety. Therefore, while, on the one hand, I do not mean to say that I believe the anonymous letter, and do not believe the agent or Messrs. Inman, it does appear to me that, considering the dreadful event which somehow happened, if the contents of that anonymous letter be true, that the ship was laden beyond the point which safety justified, a grave and serious responsibility would rest upon that agent at Halifax if he allowed the ship to leave in that state. I think it is very desirable, for the sake of Messrs. Inman, that the truth should be cleared up, and that the facts should be known. Of course, it does not follow, even if the ship were overladen, that that was the cause of the disaster. She might have come in contact with ice; she might have been lost from stress of weather, or other causes, without blame being attributable to anybody. But a serious statement has been made, and, without intending to impeach the character of anybody, that statement has only been contradicted by a person who must be regarded as an interested person. There stands for the moment the important and painful question with respect to the *City of Boston*. But the effect of my putting this question in the House of Commons was one which I had not for a moment foreseen. From a variety of quarters, and from a number of persons, some speaking from one motive and some from another, in all parts of the country, I have received communications to an extent which I had not expected pressing upon me the immense importance of this question of overloading ships. Two particular causes—constant causes of disaster—have been pressed upon my consideration. First, the relaxation of a rule which did exist, but which, for some reason or other, I know not why, has been relaxed—I mean the rule that every steamship (I do not know whether it applied to sailing ships) putting to sea ought to be provided with water-tight bulkheads. That is one point pressed upon my attention. The other point pressed upon my attention is the immense loss of life and property arising, as I say, from this neglect of water-tight bulkheads, and, in too many instances, to the fact of ships proceeding to sea laden beyond the point of safety. I have been startled by the extraordinary amount, the dreadful amount of loss which has occurred within the last twelve months—loss of life and property in steamships at sea. The facts I am about to mention have already been the subject on my part of questions in Parliament, and I think it may be as well upon this occasion, as I am alluding to the question, that I should repeat those figures. They are astounding figures. The first fact I will mention is one that I referred to in the House of Commons—namely, that from the 1st of January to the middle of March—that is to say, in the first ten weeks of the present year—there were lost no less than nine steamships. Two of these steamships were lost in consequence of those collisions to which I have already adverted. One or two of the others were stranded, and the remainder—more than half of the whole—appear to have foundered; nothing more is known of their fate. The other fact that has been brought to my notice by a simple quotation from a public newspaper is, that from the beginning of November no less than twenty-eight steamships were lost at sea. What may have happened during the months of November and December I have no information of at present. But, considering the period of the year, the too great probability is that the number of casualties was not less than in the other periods to which I have referred. But omitting these two months of November and December, and taking the six months from July to November, and then from January to March, we find that no less than thirty-seven steamships have been lost at sea. Gentlemen, I think you will consider this a subject for anxious consideration. Something surely must be wrong. I cannot imagine, with the skill of our seamen, and the skill of our naval architects in the construction of ships, that such a disastrous number of losses can have occurred in a period of six months without there being something wrong either in the construction or in the loading of these ships, or in both combined. My immediate and practical object now is take counsel with this meeting of scientific men, competent to advise, and to ask them whether they do not think that, under such circumstances, it is desirable that some member of Parliament should press upon the attention of Government that it is really due to the safety of the public and the character of our commercial navy that an inquiry should be directed with a view to the satisfactory solution of this question, to ascertain whether the difficulties are really so great that no plan can be devised for increasing the safety of our ships, and the safety of the lives of our gallant sailors, and of the passengers who go to sea in these ships. I ought not to quit this subject without reminding you that, shortly after the loss of the *London*, I brought that subject before the House of Commons; I also brought it before the Institution of Naval Architects. You will, I am sure, remember that this institution appointed a committee of competent and scientific gentlemen. That committee devoted an amount of time and labour to the inquiry which I consider most honourable and creditable to them. They produced a very able report, and that report was presented to the Board of Trade. I was sorry when I was told the other day by the Minister who represents the Board of Trade, that upon full consideration the Board of Trade did not think it desirable to carry out the recommendations that that report contained. On the other hand, without any feeling but that of a *bonâ fide* desire to increase the safety of the public, I am bound to say, from answers I have lately received in Parliament, and from public occurrences well known to you, that the impression upon my mind is that the extent to which the Board of Trade now acts, and the amount of information which is conveyed to the Board of Trade with regard to these casualties, and the inquiries which are carried on by the Board of Trade, are not so satisfactory and do not command such confidence with regard to the safety of the public, which it is very desirable for public interests they should do. I am afraid I have deviated more than I intended from my promise not to occupy your time; but the subjects on which I have touched have been so interesting, that I hope you will forgive me if I have dwelt rather longer upon them than I intended. I will now add, before I conclude these remarks, that it has been a question in the council, considering the additional time at our disposal in consequence of having four days instead of three, whether we should not relax the rule with regard to the time to be occupied with our proceedings. One rule hitherto has been that no paper should exceed twenty minutes, and that no speech in discussion should exceed ten minutes, and that the paper and speeches together ought not exceed one hour. The opinion of the council is, and I hope it will be your opinion too, that we had better adhere to that rule. And here I must ask you to exercise some feeling of compassion towards myself. It is a very distressing thing for a chairman to get up in the middle of an interesting paper and tell the gentleman he must stop. Of course I am bound to obey your rules, whatever they may be; therefore I would rather take this opportunity of appealing to those who are about to read papers to this meeting to take care so to compress their matter that the reading of the paper shall not exceed twenty minutes. I ought to apologise for having detained you so long. I will only, in conclusion, express my earnest hope that the present meeting may not be less interesting than former meetings; and that the existence of this institution may confer upon the country those advantages which I believe it is so well calculated to promote.

ON THE INFLUENCE OF THE SUEZ CANAL ON OCEAN NAVIGATION.

By Mr. J. D. Samuda M.P.

The canal connecting the Red Sea and the Mediterranean is now an accomplished fact, and without change of vessel, and without half circumnavigating the globe, means now exist for passing from the Indian seas to all the ports of Europe. The first meeting of the Institution of Naval Architects held next after the opening of the Suez Canal would be naturally desirous to take some notice of this important event, and it is with the view of considering the effects of the great engineering work on commerce, and its probable influence on the mercantile marine of all nations, that I beg to submit some facts and circumstances in connection with it. By substituting the canal route for the old-established sea voyage round the Cape, the following savings in distances are obtained in a voyage to England:—From Bombay, 5,777 miles; from Ceylon, 3,843; from Hong Kong and Singapore, 3,528; from Melbourne, 91. These savings are accomplished on voyages ranging from 12,000 to 14,000 miles in length. Roughly, therefore, the savings amount to about one-half from Bombay, one-fourth to one-third from China, and, practically, nothing from Australia. The first thing that strikes one is the enormous saving of distance thus offered to some of the principal highways of traffic, and the benefit that must result to all carriers from availing themselves of this shorter route. But it had been foreseen, and is now universally admitted, that, independently of the difficulty and the expense of towing sailing vessels through the canal, the navigation of the Red Sea is so unsuited to them at most times, that the owners of sailing ships must regard the canal route as wholly unsuited to their use. Considerable depression has naturally resulted in this class of property, and the production of sailing ships since the opening of the canal has been almost if not entirely stopped. Is this depression to be temporary, and will the experience of subsequent working justify the conclusion it points to of a general substitution of steam for sail in the great carrying traffic from the East? To arrive at any sound conclusion on this most important subject it will be desirable to review by the light of our present knowledge the capability of steam vessels for dealing with all or a part of this new field suddenly thrown open to them. And here I would observe that if the opening of the canal had taken place eight or ten years earlier scarcely a cargo-carrying steamer of any sort would have entertained the idea of profitable employment on even the most favourable of the routes. But the interval of time has been so profitably employed by steam-ship owners realising the importance of economy of coal and the improved proportion of vessels and engines, that voyages may now be undertaken with profitable results which only a few years back would have been hopeless, except in cases where large subsidies were obtainable, to compensate the great cost of coals and working compared with the carrying powers of steamers then in use. The first great and important change in the character of cargo-carrying ocean steamers within my own experience occurred in 1863, when a large foreign company, who had till then, on a 4,000 mile journey, employed vessels burning forty tons of coal per day to carry about 1,400 tons of cargo, were able to substitute them by vessels burning fourteen tons of coal and conveying 2,000 tons of cargo. And the new vessels made nine knots of speed, actually averaging a higher speed than the old ones. The effect was so startling that it led to the entire fleet being gradually replaced by the economical vessels. I think that economical working of steam applied to cargo-carrying requires that coal should be, if possible, taken on board before leaving England for both the outward and the homeward trip. Our present experience shows that with a vessel of 2,000 tons, builders' measure, giving an average of nine knots, and burning fourteen tons per day, coal may be carried for the round voyage of 12,000 miles—6,000 out and 6,000 home, and leave space to carry 1,600 tons of cargo out, and 2,000 tons home. With those conditions, it appears probable that a large amount of success may be accomplished. If this be so, we may regard as the natural consequence of the opening of the canal, that the whole, or at least the greater portion of the traffic between Bombay and England will be lost to sailing vessels, and appropriated by steam. When, however, we deal with the China traffic, the difficulty for steam is much increased. Here a complete voyage of 20,000 miles has to be provided for, and I cannot satisfy myself that the same beneficial results will follow. With exceptionally high freights it may be possible to compete with first-class sailing ships; but as the same vessel referred to above would, on this longer voyage, under similar circumstances, only be able to carry 1,000 tons of cargo out and 1,800 tons home, it is doubtful if steam will do more than obtain a limited portion of the traffic, and that the superior clipper ships may look to retain their vocation for some time; that is, till further improvements in steam, in the same direction as those that have been made in the last eight years, put them in a position to compete successfully for cargoes on this increased length of voyage. Then, as regards the Australian traffic, where no advantage of distance whatever is to be gained by using the canal, and where the length of the voyage is again increased, I look upon the profitable employment of cargo-carrying steamers as at present impossible, and that route, of course, will be left to the sailing ships untouched. I am well aware that the drawing off of sailing ships from the Bombay route will cause a serious competition to those on the Australian station. I also think that the development of Indian railways will shortly bring to the port of Bombay much produce that now comes from Calcutta and other ports of India; and that gradually and shortly Bombay will become the great port of India for England. But as these latter changes are more or less matters of time, and as the life of sailing ships does not range over very many years, I do not see sufficient cause to justify the panic that appears to have overtaken this class of property; and I am inclined to think that their substitution and extinction will be much more gradual than the possessor of them apprehends. I do not wish to be understood as suggesting that improvement has reached its limit; I look to progressive and very considerable improvement in both ships and engines, and imagine that a source of economy will be found to result greatly from the substitution to a large extent of steel for iron in the hulls of vessels, and from simplifying the construction, and carrying still further the system of expansion in the engines. And, doubtless, the due encouragement of those who are continually, from their skill and experience, able to develope improved results in a particular form, will have much influence in shortening the periods of their attainment. Such encouragement, however, I regret to say, is the exception, not the rule; for with a short-sighted policy, accepting, indeed, the Manchester school for a platform, which in great degree permeates the whole of our commercial catechism, the one ruling idea that purchasers cling to appears to me to be price—the lowest price at which anyone can offer to throw together materials and labour to produce the article sought. The argument seems to be a ship is a ship; if it has certain tonnage, power, and has passed a certain official inspection and registration, that is all that is desired. And unless skill, experience, and faithful work can present themselves with the lowest tender, they need not take the trouble to offer their services: or, at all events, they will generally find themselves wholly ignored. I think this general disregard for all works of character, and the substitution of the mere standard of price, is one of the greatest misfortunes that commerce has fallen under during the last quarter of a century. It has developed the wrong energies of the producers—has taught men to rely for success upon the production of plausible shams, and has implanted a lower standard of production—a less worthy aim to all producers throughout the kingdom. These remarks certainly do not apply only to shipping; all other manufactures are equally obnoxious to them. But inasmuch as shipowners are entrusted with a much higher mission than most others, and bear in every instance the heavy responsibility of having much human life dependent upon their care, it is of the utmost importance that they should take a prominent position in discountenancing the general decadence of commercial morality. Again, I am not sure that the power of obtaining immunity from loss by insurance has not been carried too far, and may in some degree have served to prevent the consideration of the weighty responsibility that errors of judgment, or a too ready acceptance of general usage, lays upon them; and I am by no means certain but that our legislature might confer great benefit, and greatly improve the existing state of things, if our contemplated Merchant Shipping Bill were to render it obligatory on every owner to retain at his own risk uninsured one-fourth, or one-third, of every vessel sent to sea. Recurring to the original subject of this paper, I cannot fail to remark that we must be prepared, and mainly through the opening of the canal, for a large share of the carrying trade of the East passing from ourselves to other nations. Russia, France, and Germany are all too anxious to avail themselves of any means of improving their navies to disregard the opportunity this offers them of subsidising commercial undertakings and practising their naval officers. Silk, tea, and cotton, and other produce of the East will certainly pass in large quantities in vessels of those nations to their own ports instead of being reshipped as now, in most instances, after reaching England. I am quite alive to the importance of this result, and to the weighty consequences of it. It certainly will have the effect to a considerable extent of diverting trade from our country, but I do not regard this with absolute alarm. Every one must have foreseen that since the large discoveries of gold the countries that obtained it from us in exchange for their productions, would not be content to leave us in the undisturbed position we previously held as the workshop of the world, and that they would gradually avail themselves, as they have done, of the resources which the possession of gold, gave them for raising manufactories and fleets to appropriate to themselves some of the advantages we had so long derived from its exclusive possession. But such large new fields of commerce are being daily opened to us, such increased wants from an increasing population and the improved power of purchasing, that I have no great fear for the extent of operations. What I fear much more is, that, in the desire to possess more than our proper share, a system of unsound trading and reckless competition among ourselves may continue. I say may continue, for I believe it exists in full force at present; and that we may be deprived of much of our legitimate reward in this country from the fact of everyone trying to obtain more than his fair or reasonable share of it. It has formed no part of my intention in this paper to comment upon the construction of the canal itself, the difficulty and cost of keeping it open, of preserving the required depth of water in its harbours, of maintaining its banks from the action of the traffic passing through it—all matters of great interest to its proprietors, and which, indirectly, will no doubt exercise an important influence on those who use the route. But I cannot refrain from expressing surprise that the design should have adopted Port Said and avoided the use of Alexandria as the European port. One would imagine that the advantages of debouching at the back of Alexandria Harbour would have been so apparent that the whole surveys and arrangement would have accepted this condition as the best. Can

French influence have caused this diversion in the expectation that their desire to obtain sovereign right over this great waterway between Europe and India would have passed unchallenged if the territory they desired to annex did not enclose the port of Egypt? Or can the existence of any great engineering difficulty have led to the decision? One can hardly imagine this in a desert and flat country such as Egypt. But whatever the cause, there can be no doubt of the disadvantage of Port Said as compared with Alexandria. There is now to be encountered the doubt and difficulty, and the enormous expense that continual operations on the harbour of Port Said must entail. And looking to the fact that nature has, from a time beyond the record of history, choked the present harbour of Said with the delta of the Nile, and will doubtless continue to offer the same obstacle to its being kept open, and tax the ingenuity of the engineers and proprietors to prevent this result, a great anxiety, to say the least, might have been avoided. Again, vessels on their journey eastward would have been saved 120 miles of sea voyage—some twelve hours' steaming—for they are not in any degree further on their road when entering Port Said than they are at Alexandria, which is that distance short of it. As regards the carriage of passengers and mails especially, this will exercise a most damaging influence, and may even result in maintaining a change of vessel at either end of the canal, and continuing the overland route as at present, to avoid the increased delay which must of necessity otherwise take place from the slower passage than hitherto through the canal being so greatly aggravated by the additional 120 miles of sea voyage, resulting, as it doubtless would, in a delay of twelve hours in the delivery of all letters by each Indian mail. Again, in addition, in Alexandria they would have to deal with a well-known and magnificent harbour, even as it at present is, and which is capable of any extent of improvement, instead of having to encounter the discomforts and difficulties which nautical men say with certain winds and weather invariably affect the usefulness of Port Said. I will not enlarge upon this point. In conclusion, I trust that the success of the undertaking will be maintained. A new field has been opened to the commerce of the world. This country has with characteristic enterprise been the first to avail itself largely of the facilities it has offered. The prospects of the canal have been reported as improving daily since its opening. But whatever benefits experience may show to accrue to the promoters, I feel sure that the Institution of Naval Architects of England will not allow this general meeting, at which it has the first apportunity of referring to so great and useful a project, to pass without expressing sympathy and admiration for the talent that has projected and the perseverance that has accomplished this great naval work of modern times.

IMPROVED FAN BLOWER.

The following description of a "Multiplying Pressure Fan" is abridged from the *Scientific American*, and as it appears to us to be an invention of considerable value, we trust it may be found interesting to our readers:—

The fan blower has held a position as a standard machine for about forty years, the first having been built by Braithwaite and Ericsson in 1829.

The high speed at which it has to be driven, and the consequent great consumption of power and excessive wear and tear, have justly been considered serious objections to it. Notwithstanding the many attempts made to overcome these defects they still exist. Clark's multiplying-pressure fan blower, illustrated in the accompanying engravings, attains the desired end. It gives the requisite pressure without high speed, and yet has all the simplicity of the ordinary fan blower.

The illustrations represent the form of the blower, and also a longitudinal sectional view, enlarged, of one of the bearings, and the adjustable device connected therewith. Fig. 1 shows one of these blowers that multiplies the force of the blast four times. Fig. 2 is an enlarged view of the bearings with an improved mode of adjustment.

The blower is made in compartments, each of which is formed exactly like the others. In fact each compartments i a well-constructed fan blower, receiving the air at the centre and delivering it at the circumference, where it is forced over the edge of the disk, C, through the annulus between the disk, C, and the shell or case, A, in the direction of the arrows, and thence down between the disc, C, and the opposite side of the shell, A, to the centre of the next fan, by which it is received and delivered exactly as in the first, and so on through the whole series, whether the number be four or more.

The passages leading from one compartment to the next may seem tortuous and difficult for the passage of the air, but they are made in all cases eight times greater in area than would be required to deliver the air under pressure at the point of final delivery, and as the resistance to the flow of aeriform fluids diminishes in the ratio of the square of their velocity, the loss from that source being only $\frac{1}{64}$, becomes insignificant.

Fig. 2 shows a plan by which the shaft may be moved lengthwise, so that in the event of of the fans in either compartment touching the side of the shell they may be easily adjusted. The journal box (Fig. 2) is a hollow tube lined with Babbit metal; a plano-convex ring fits over this tube; this ring is cut in the line of its axis, so that by compression it may be made to gripe the journal box. A hub, so formed as to receive one-half the plano-convex ring, is held in the centre of the central opening by the three arms, as shown. Another hub, made to fit the other half of the plano-convex ring, is secured to the first one by bolts. When the bolts are slack the journal box may be moved endwise, but when they are tight it is held firmly in place.

The *Scientific American* says:—"We have seen this blower tested, and can assure our readers that it accomplishes what its inventor claims for it; we have seen it with a pressure gauge on each compartment, and invariably the gauge on the fourth one indicated a pressure four times greater than that on the first. We have been shown very flattering testimonials from some of the best foundrymen and machinists in the country, respecting this blower. It is no longer an experiment."

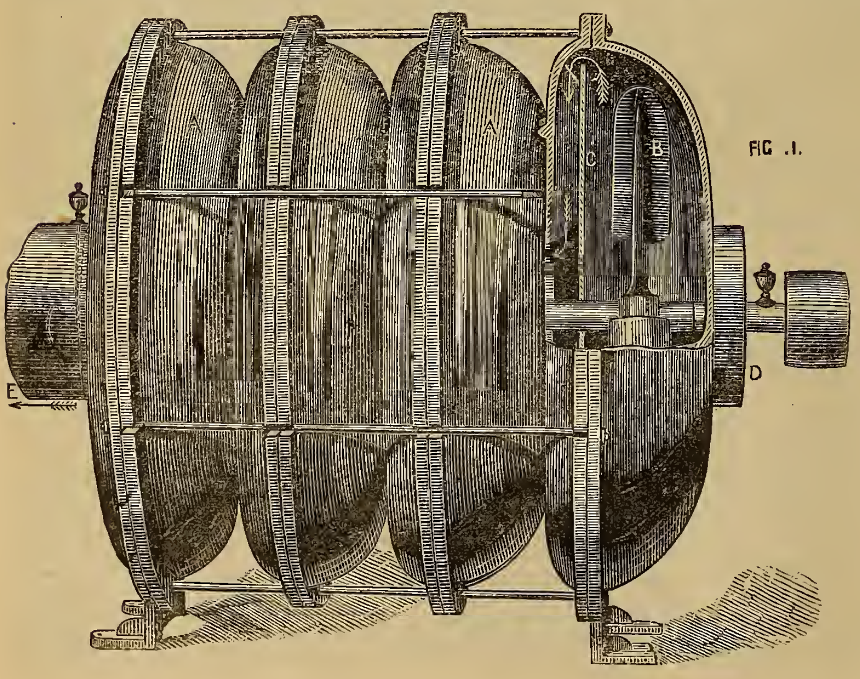


FIG. 1.

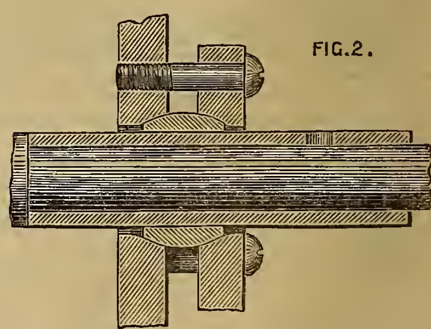
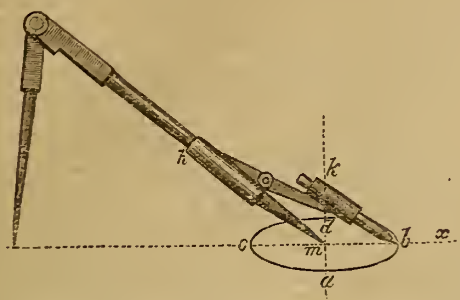


FIG. 2.

A NEW ELLIPSOGRAPH.

The compass for drawing ellipses, illustrated in the accompanying cut, is a German invention. Its operation is based upon the truth, that by cutting a cylinder in an oblique plane, the edges of the cut surface will form an ellipse. The instrument is designed to trace a curved line by an ordinary movement of rotation, but under such conditions as will secure the same results as in such intersection of a cylinder.



The two arms, properly so called, of the compass remain fixed with their points on a line, *x*, the instrument being held in a vertical plane, as indicated in the figure. A sleeve, *h*, to which is jointed a third arm, *k*, is capable both of sliding upon the adjacent arm of the compass and of turning around upon the same. This supplemental arm, *k*, carries the pencil or tracing point, *b*. In turning the sleeve, the point, *b*, describes a circle equal to that of the circumference of a cylinder having for its axis the longer arm of the compass. While this is being done, care is taken to allow the sleeve to slide upon the arm to which it is attached to an extent sufficient to enable the point to be kept constantly in contact with the paper upon which the ellipse is to be marked.

From this double movement it results that the point, *b*, is, as it were, simultaneously on the surface of a cylinder and on a plane oblique thereto, and, as a consequence, the line traced upon the paper is a perfect ellipse. The larger radius of the ellipse is indicated at *m b*, the smaller at *m a*.

In order to use the instrument, the fixed points of its two arms are placed upon the line, *c x*, corresponding to the longer axis of the desired ellipse, and the point, *b*, is placed in the line of the shorter axis and at a distance from the point, *d*, of the longer arm equal to the length of the shorter radius, the angles of the two arms being adjusted to permit the point, *b*, to pass from one position to the other, whereupon the ellipse may be drawn in the manner above described.

REVIEWS AND NOTICES OF NEW BOOKS.

Abstracts of English and Colonial Patent Specifications, relating to the Preservation of Food, etc. By William Henry Archer, *Registrar General of Victoria.*

The high price of butchers'-meat, has induced men, in the spirit of enterprise, to endeavour to satisfy economy, on the one hand, and, on the other, a sympathy with the relatively poor, by seeking out the means of increasing the supply, and thus lowering the price. The abundance in Australia naturally invited attention, and the distance became the difficulty, and positive impediment to bringing here the beasts, alive or dead. Many are the methods which have been tried, and the Englishmans' courage in the face of difficulties, has been repeatedly and severely taxed, to end, as yet, in failure, or but partial success at best. The brochure before us is evidently compiled with the laudable intention of bringing past failures before us, the better to avoid the vexation of their reintroduction, and economise the expenditure of the enterprising. Parties who entertain the question of "preservation of food" will do well to examine these pages with care, for they must be invaluable to such. The descriptions are illustrated by many well executed lithographed plates, and the technical getting up reflects credit on draughtsmen and printers.

The Science of Building. By E. Wyndham Tarn. London: Lockwood & Co.

We have here an "elementary treatise on the principles of construction" from which we rise in pleasurable sympathy with its contents. Those contents are not palmed off on us as original—although some of the most important of them are—but selections from the best authorities. The quiet, neat, scientific appropriateness of the language employed, distinguishes the master mind from the fussiness and confusion of the pretender. Other authors are mentioned, to guide the student, where profounder depths, or greater heights may be desired. This little work must be as welcome to the student in Architecture as to the student in Engineering; for both these students must, sooner or later, be familiar with every word here brought together by experience in theory and practice.

The articles on Building-stones, Wood, Iron, &c., are also appropriate. In a word, we have just so many stages for the student to stand on and erect his contemplated superstructure—possibly a temple to fame—but the durability, and the height to which his structure may rise, must invariably depend on his own intelligent industrious use of such stages. We have no ready-made Architects, nor ready-made Engineers; nor can they be made to order. Sir Humphrey said, "what I am, I made myself." Of course much depends on a good beginning, and the possibility being afforded, the student has to avail himself of every opportunity, and he will seek for more opportunities, if he has commendable energy of character and a cultivated taste, or die a drone as he lived.

The diagrams elucidating the contents, are clear and sufficient. The work is got up with modern neatness, good type and paper, with margin.

Principles and Construction of Machinery: A Practical Treatise on the Laws of the Transmission of Power, and of the Strength and Proportions of the various Elements of Prime Movers, Mill-work, and Machinery generally; arranged for the use of students, engineers, and practical mechanics. By Francis Campin, C.E. London: Atchley and Co.

Such is the elaborated title of the little book before us. Our author's claims to notice are candidly fore-shadowed in his "preface." We there learn that completness was avoided; for a larger work would have been "cumbrous to the last degree;" that this work is not profound, because it is "the substance of the author's oral instructions," and he desires to "try the faculties of the mind as little as possible," and we congratulate him on his success; for he leaves us on the threshold of knowledge, when introducing us to his "alphabet of engineering practice."

The book is well got up; the printing and binding unexceptionable; being neat, clear, and strong. Its unequal contents may be useful to many, and variety is always interesting. The book may thus become positively beneficial whenever it whets the appetite, which distinguishes the engineer, for more knowledge. He must be daily progressing, on the surface, or into the profoundity of science, and of experience.

We do him but simple justice when we allow our author to speak for himself. Now, the definition of the lever and its functions becomingly occurs among the earliest lessons of the pupils. His yet insufficiently trained mind requires clearness, distinctness, and correctness to help him to comprehend aright so many novelties to him, if not positive paradoxes. "If two forces act about a centre," says our author, "so as to preserve equilibrium, *acting of course in opposite directions*, their moments must be equal." We might be content with this much, but to ensure perfect contentment in others also we will go with him a little further. "Let a force of 30 pounds act about a centre, at a distance of 3ft. from it, the moment of force will be $=30\times3=90$ foot-pounds; at what distance from the same centre must a force of 12lbs. *act in the opposite direction* to balance this moment? * * * * In this case if the forces were rotating," &c. Experience sees clearly at what our author is aiming, and sees also that he misses his mark. The italics are ours, and possibly indicate the position which we are disposed to take. Here are two forces, acting of course in *opposite directions*, about a centre, and of course the result must be motion, and not equilibrium or rest. The entanglement of words tends to beget confusion, if nothing more, instead of respect for the subject taught. Here the scale-beam may become a suitable illustration, as it has been many a time agone; there we find the two forces which produce equilibrium are the weights, and being equal, the result is rest. These two forces, acting by gravity, act in the *same direction*. If one of them acted in "*an opposite direction*"—say upwards—we must, "of course," have motion, and not rest, which, "of course," cannot be the author's intention, although it be the inevitable interpretation of the author's inappropriate language. If he sacrificed sense to brevity, it is evident that his sacrifice was too great.

It is satisfactory to see here also a relative position maintained for chemistry, among the varied qualifications incumbent on an engineer.

Our Domestic Fireplaces. A New Edition. By Frederick Edwards, jun. Longmans, Green, and Co.

Here is a cosy work for cosy people to read; and the author himself assures us that it is terminated "with no little satisfaction," leaving us, smaller creatures, no alternative but to be satisfied also. He condescends to informs us of his "endeavours to enlighten the public upon the various matters connected with the domestic use of fuel," to which his "no little satisfaction," without doubt applies. This amiable gift of self-complacency pervades the book before us. The language is not the "dog latin" of scientific men, but every day English, the popular idiom, so that it is likely to become a welcome visitor. Its range is a wide one—no pun intended—and the subjects are as varied as interesting to most people. It recognises the bellows of antiquated domesticity and its companions in age—the warming-pan, folding screen, &c., and invites our attention to modern improvements, and to "other ameliorations of home comforts." We have, too, the "use of coal in fireplaces," which, although it is not announced as a positive discovery, is most assuredly a subject which deserves to be better understood generally, on the score of economy as well as of comfort. We get a glimpse of the progress of civilisation, in the advance of improvement of the comforts of an Englishman's fireside. Here are neatly executed plan, elevations, and sections, with suitable instructions, presided over most appropriately by Count Rumford. As the word "comfort" is essentially English, and this book shows, in a popular manner, how to realise comfort, it follows that such a book must become popular among they who desire comfort—that is, among Englishmen in particular, and the world in general.

Formules Approximatives de Construction Navale. Par J. A. Normand. Paris: Arthur Bertrand.

The author says a few years since he published a succinct treatise* of a method which seemed to him calculated to supply and perfect the system of naval construction. This treatise, he says, was purely theoretical. In the work under notice he presents us the completion of his work, having rectified some errors, and having assured himself, by constant practice, of the correctness of the principles upon which his calculations were based. The work is illustrated with woodcuts, by numerous tables and plates, showing the lines of various classes of vessels, ranging from lifeboats and yachts to armour-clad vessels of war, most of which seem taken from English models.

Obituary.

THE LATE THOMAS JOSEPH DITCHBURN.

The late Mr. Ditchburn served his apprenticeship in Chatham Dockyard, under the celebrated Sir Robert Seppings, with whom he was a favourite pupil, being much employed by him in making models, and trying experiments in connection with his numerous inventions. About the year 1824, he undertook the management of the extensive shipbuilding establishment of Messrs. Fletcher and Furnell, at Limehouse, but while engaged here in constructing wooden vessels, he became convinced that iron was a better material than wood for shipbuilding purposes, and at once set about establishing himself in business as a builder of ships of iron as well as wood. To facilitate this object he entered into partnership with Mr. C. J. Mare, and commenced work at Deptford. The first iron ship launched by the firm of Ditchburn and Mare was built for the Russian Government, and was named the *Inkerman.* She was a small vessel, of shallow draught of water, and was so great a success that the new firm immediately afterwards obtained orders for several small vessels to run between the bridges in London. These little vessels were named *Starlight*, *Daylight*, *Moonlight*, and *Twilight*; their engines were made by Messrs. John Penn and Son, of Greenwich, and they are now in existence, and were carrying passengers within the last few years, although nearly thirty years old. So great was the success of these iron boats that the firm were immediately employed to build numerous iron river boats, of various sizes; several for the London and Woolwich service, others for the Gravesend and Margate, and Ipswich companies, and also many larger vessels for the General Steam Navigation Company. Indeed, orders came in so rapidly that the firm found it necessary to seek for better and more extensive premises; the result was the establishment of the works at Orchard House, Blackwall, now in the occupation of the Thames Ironworks and Shipbuilding Company. Mr. Ditchburn's name now became known all over the world, and vessels of every description were rapidly constructed for numerous companies and corporations, as well as for the British and foreign governments—in the North Sea, in the British and Irish Channels, up the Rhine, in the Mediterranean, the Black Sea, on the Swiss lakes, and on the English and Scotch rivers, iron steam vessels designed by Ditchburn, and constructed by Ditchburn and Mare, were found, making the advantages of the new material known, and laying the foundation of nearly all those lines of steamers now so numerous and celebrated. About the year 1844 Mr. Ditchburn was employed by the Lords of the Admiralty of the day to construct for her Majesty's private use a steam yacht, which he did, and it was named the *Fairy.* Having narrowly watched the experiments of Ericsson, "screw" Smith, and others then being made, Mr. Ditchburn became so thoroughly satisfied that the screw propeller was an improvement on the paddle wheel for most purposes, he persuaded the authorities to adopt that mode of propulsion. The *Fairy* was accordingly fitted with a screw propeller, which screw was the first screw propeller ever used in the British Navy; and so excellently was the whole thing done, that until quite recently the *Fairy* remained one of the best results of that method of propulsion.

* "Memoire sur l'application de l'algèbre aux calcules de bâtiments de mer." Paris Arthur Bertrand, 1864.

NOTES AND NOVELTIES.

MISCELLANEOUS.

Dr. Ott has published a memoir on timber-preserving processes. He says the opinion that carbolic acid and substances containing it are effectual in preserving timber is erroneous. The real preservative action of the tar oils is due, according to the author, to a greenish fluorescent oil that comes over at the last stage of distillation. Direct trials with pyren and paranaphthaline do not yield successful results. The question whether coal tar contains a sufficient quantity of the flourescent greenish oil just alluded to, to justify the use of such tar for preservative purposes, is answered in the negative. The decay of timber, or peculiar transformation which makes it unfit for practical purposes, seem, to be in most instances produced by the attacks of fungi and lichens. The mouldering of wood is distinct from decay, it being merely a chemical process caused by the action of water with small access of air.

Gas Steam Boilers for Lifting Purposes.—Mr. Jackson, who has invented a steam boiler in which gas is the generating power, and which is specially applicable for lifting purposes, invited a number of gentlemen connected with the warehousing business and with mechanics generally, to witness the practical operation of his invention at the East and West India Dock Tea Warehouses in Hart-street, Crutched Friars. The great merits claimed for the invention are economy of space, economy of labour and fuel, combined with perfect freedom from risk of conflagration. At many of the largest warehouses in the City the system has, it is stated, been for several months at work, with perfect satisfaction. As to economy in the matter of fuel, we are told that one horse power is maintained for ten hours at the cost of 1,000 cubic feet of gas, charged according to the varying cost of the London gas companies, at from 3s. 3d. to 4s. 6d.—the latter maximum figure being, we believe, confined to the London. Another economical point is that when the work is suspended the gas may be reduced to a minimum consumption without losing the generating heat power necessary for resuming operations at a moment's notice. The dock authorities at the warehouses express themselves thoroughly satisfied with the invention.

Gas for San Paulo.—A prospectus has been issued by the San Paulo (Brazilian) Gas Company (Limited), with a capital of £70,000, in shares of £10, to carry out a concession which has been purchased for £3,500 for the introduction of gas into the city of San Paulo. The concession is exclusive for 25 years from the 9th of July, 1869.

The Warsop Aero Steam-Engine.—The steam-tug *Fuh Lee,* intended for service in the Chinese rivers, and fitted with the Warsop aero steam-engine, has been heard of from Gibraltar, on her outward voyage; and her engines seem to have fulfilled, or even surpassed, all anticipation. Her captain writes "the aero steam system is invaluable to us," and then, going into details, he reports that he has carefully weighed his coal, and that he has had a consumption of only two and a half tons in 24 hours, working the vessel against a heavy lumping sea, that has severely tried her capabilities. Her engines of the *Fuh Lee,* are of 60-horse power nominal.

LAUNCHES

The firm of John Elder, Fairfield Shipbuilding Yard, Govan, launched on the 26th March the largest merchant ship in the world, with the exception of the *Great Eastern.* As she left the ways she was gracefully christened the *Italy* by Miss Thorneycroft, of Wolverhampton. The *Italy* has been built to the order of the National Steamship Company of Liverpool, and is intended for their service between Liverpool and New York. She has a dead-weight carrying capacity of 3,300 tons, and is fitted to carry 100 first-class and 1,500 third-class passengers.

There was launched on the 24th March from the shipbuilding yard of Messrs. J. and R. Swan, Kelvindock, near Glasgow, an iron screw steamer of 90 tons burthen, named the *Louisa.* She is owned by Messrs. J. and J. Hay, Glasgow, and is intended for the Forth and Clyde navigation and general coasting trade.

Messrs. Alexander Stephen and Sons launched, from their works at Kelvinhaugh, a new iron sailing ship of 851 tons, named the *Maggie Trimble,* the highest class at Lloyd's and in Liverpool Registry. The ship is to be employed in the Eastern and general trade, and has been built for R. G. Sharp, Esq., for whom Messrs. Stephen have built a series of fine iron ships.

There was launched on the 2nd ult, from the building yard of Messrs. John Fullerton and Co., at Monksworth, a screw-steamer of the following dimensions:—Length, 130ft.; breadth of beam, 20ft.; depth of hold, 10ft. The vessel was launched broadside into the Cart, without the slightest hitch in the operation, and was named *Glengarnock* by Miss Dunn, as she glided off the stocks. The *Glengarnock* has been built to the order of Messrs Merry and Cunninghame, and is to be supplied with a pair of direct-acting condensing engines of 42 horse-power, by Messrs King and Co., Dock Engine Works, Glasgow. She is to be classed A1 at Lloyd's.

There was launched on the 2nd ult., from the building yard of Messrs. John Humphrey and Co., Aberdeen, a fine clipper ship, which was named by Mrs. Connan the *Craigendarroch.* She is about 1,200 tons builders' measurement, and 1000 tons register tonnage, and her figure-head represents a Highlander in Invercauld tartan. This fine vessel has iron beams, and a Humphrey's patent iron keelson, on account of which she has been awarded by Lloyd's Committee for Shipping Registry the highest class ever granted to any vessel of the same material. We understand that the *Craigendarroch* has been built to the order of Messrs. Richard Connan and Co., for the South Australian trade, and when fitted out will take her place in the Elder line of packets between London and Adelaide, with her sister ships *Carnaquheen* and *Bundaleer.*

There was launched on the 5th ult from the building yard of Messrs. Caird and Co., Greenock, a beautifully-modelled spar deck steam vessel, which was named *Australia* by Mrs. Methven, wife of her future commander. The *Australia* belongs to the Peninsular and Oriental Steam Navigation Company, and is of the following dimensions, viz.:—Length of keel or forerake, 370ft. (over all 401ft.); breadth of beam, 44ft.; depth of hold, 36ft.; tonnage (builders' measurement), 3,538 tons. She will be propelled by engines constructed by Messrs Caird and Co. on the most improved principles, and of 600 horse-power nominal. Besides provision for a large number of first and second class passengers, the *Australia* will carry 1,800 tons of cargo and 1,000 of coal, while arrangements can be made whereby 2,500 tons of cargo can be stowed by reducing the passenger accommodation. The *Australia,* we believe, is the largest steamer ever launched at Greenock.

On the 11th ult there was launched from the shipbuilding yard of Messrs M'Culloch, Patterson and Co., Port-Glasgow, a sailing barque of 700 tons, built to the order of Messrs. John Hay and Co., of Liverpool, which on leaving the ways was named the *Vale of Nith,* by Miss Mary Hay, sister of the managing owner. This vessel is now being loaded in Kingston Dock, by Messrs Aitken, Lilburn and Co., as one of their clipper line of packets for Sydney.

TRIAL TRIPS.

Trial Trip.—On the 11th ult, the steamer *Helene,* which has been built by Messrs. Wm. Hamilton and Co., Port-Glasgow, to the order of Messrs. N. A. Theodoridi and Co., of Constantinople, for the Imperial Ottoman Government, underwent her trial trip. The boat is 180ft. long by 21ft. 3in. wide, and 9ft. deep; and is fitted with oscillating engines of 100 nominal horse-power, made by Messrs. John and James Thomson, Finnieston Engine Works, Glasgow. The cylinders are 38in. diameter, and the stroke 3ft. 9in.; and she is also supplied with feathering paddle-wheels, and rounded tubular boiler. This is the second steamboat that has been built and fitted up by the same firm for the Turkish Government. After clearing the harbour the vessel sailed down under easy steam to the Cloch Lighthouse, where the first trial was to take place. Time was then taken by Messrs J. Williamson and Lapthorpe, two of Lloyd's surveyors, who were on board for that purpose, and full speed put on for a run to the Cumbrae Lighthouse, and this was accomplished in 55 min. 17 sec., the vessel having gone at the rate of 14·6 knots, or about 17 miles an hour, and this, too, against a strong head wind. The engines worked easily and smoothly, giving from 48 to 50 revolutions per minute, with a steady pressure of from 35 to 40lb. on the square inch. Having completed this task the vessel's head was turned round, and sail was made for the measured knot at Skelmorlie, where her speed was again put to the test. The knot was run in 3 min. 57 sec. being at the rate of 15·1 knots, or 17½ miles per hour. This was deemed highly satisfactory, as the guarantee given was that the vessel would steam 14 knots an hour, and in both trials she considerably exceeded that distance. We believe the *Helene* is intended for the passenger trade on the Bosphorus, and is therefore fitted up with every convenience necessary to render a sea voyage in that quarter of the world pleasant and agreeable.

Trial of H.M.S. Vanguard.—The iron, armour-plated double screw steamship, *Vanguard*, 14, had her six hours continuous trial outside Plymouth Sound, on the 9th ult., Capt. Luard, of the *Indus*, and Mr. Steil, from Whitehall, superintended, assisted by Staff Commander Pounds, Mr. Nicol, and Mr. Barden, from Keyham Steam-yard. Mr. William Laird, of Laird Brothers, who built the ship and engines, and their engineer, Mr. R. R. Bevis, were also on board. Wind, westerly, force 4 to 5, which increased towards the close to 6 to 7, the sea rising proportionately. The *Vanguard* left the Sound at 10 a.m., under easy steam, and at 10.50 started on a course almost due south to keep the wind on her beam. During the six hours she maintained a mean speed of nearly 14¾ knots, the results every half hour being as follows:—First half-hour—Pressure of steam, 30lb.; mean revolutions, 73·71. Second half-hour—Pressure of steam, 33lb.; mean revolutions, 73·29. Third half-hour—Pressure of steam, 30lb.: mean revolutions, 73·83. Fourth half-hour—Pressure of steam, 28½lb.; mean revolutions, 72·98. Fifth half-hour—Pressure of steam, 28½lbs.; mean revolutions, 72·64. Sixth half-hour—Pressure of steam, 30lb.; mean revolutions, 73·24. Seventh half-hour—Pressure of steam, 30lb.; mean revolutions, 73·24. Eighth half-hour—Pressure of steam, 26½lb.; mean revolutions, 71·06. Ninth half-hour—Pressure of steam, 26½lb.; mean revolutions, 71·31. Tenth half-hour—Pressure of steam, 26½lb.; mean revolutions, 71·09. Eleventh half-hour—Pressure of steam, 26lb.; mean revolutions, 70·26. Twelfth half hour—Pressure of steam, 25½lb.; mean revolutions, 69·88. The true mean number of revolutions was 72·20 per minute, which, compared with 73·66 attained at the measured mile, gives a mean speed of 14·65 knots per hour. The vacuum in condensers during the present trial was 26 to 26½. The coal used was Powell's Duffryn, supplied from the dockyard. The engines of the *Vanguard* are of 800 horse-power; there are four cylinders, each of 72in. diameter; the length of stroke is 3ft., and the weight of cylinders 54 tons, and of the condensers 40 tons; the length of brass tubes is 14¼ miles. The two screws are two-bladed Mangin; diameter, 16ft. 2in., with a pitch ranging from 19ft. to 21ft. Total weight of machinery and boilers fitted with spare gear (actual weight) is 739 tons 10cwt. 1qr. 10lb. The number of boilers is six, and of furnaces 24. The number of tubes is 2,904; the length is 6ft., the outside diameter being 2¾in.; the total heating surface is 15,201 square feet, or 19ft. per nominal horse-power. At the trial the *Vanguard's* draught of water was, when going out, forward, 20ft. 6in.; aft, 21ft. 6in. She is fitted with a balance rudder. At her official trial on the 6th ult., six runs at full boiler power produced a mean of 14·944 knots per hour, and four runs at half-boiler power, a mean of 12·742 knots. The nominal power of the *Vanguard's* engines is of 800-horses; during these trials at full boiler the power indicated was 5,365 horses, at half boiler 2,751. Load on safety valve, 30lb. Pressure of steam in boilers, 30lb. Vacuum in condensers, 26.

RAILWAYS.

The railway between Bombay and Calcutta has been opened for through traffic.

The works on the Dublin and Antrim Junction Railway have been recommenced, and the line is to be completed before July, 1871. The length of line is eighteen and a-half miles, and when open it will afford the shortest route to Dublin from Antrim and all stations north of Antrim on the Northern Counties Railway. The contractor for the works is Mr. Tredwell, of Birmingham.

The Skye line now being constructed by an independent company will be opened for traffic on the 1st of July next, by which a new and expeditious route between Edinburgh, Glasgow, London, and all parts of the south and the north-west Highlands and islands of Scotland will be opened to the public. The traffic which will flow over this route will traverse the Highland line from Dingwall to Perth, a distance of 162 miles.

The Great Indian Peninsula Railway.—The railway extension to Jubbulpore was opened on the 8th March last, and the break between Nagpore and Jubbulpore having been spanned, and Calcutta and Bombay having been brought into direct railway communication, it was formally declared open by the Viceroy. The Viceroy remained a day at Jubbulpore, and the next day saved about eighty miles of journey by travelling down the Cord line. There was no ceremony over the "last key" of the latter, but the Viceregal train having traversed, it may be accepted as proof that it will soon be open to the public. Lord Mayo also declared open the small branch line from Khangaon into the cotton districts, and made himself acquainted with the coal features of the Chanda fields, travelling about two hundred miles into the heart of the coal and cotton country.

The undertaking of the Indian Tramway Company, from Arconum to Conjeveram, about 19 miles in length, is incorporated in the Carnatic Company, and it is intended to extend that line to about five principal places in its route to Cuddalore. The extension line will be about 120 miles in length, and pass through a populous and fertile country. The exact route will be determined by the by the Madras Government. They will have to cross one large river and a smaller one. There may be a branch from the railway to Pondicherry, as the traffic will be large.

TELEGRAPHIC ENGINEERING.

A Telegraph to Portugal and Gibraltar.—A telegram from Lisbon states that the public adjudication of concession for the construction of telegraphic lines between England, Portugal, and Gibraltar was made on the 4th ult. The Minister of Public Works announced that the concession has been definitely granted to M. Jules Despecher, the representative of the Falmouth, Gibraltar, and Malta Telegraph Company.

Post-office Telegraphs.—The number of telegraphic messages sent out for delivery in the City of London in the week ending 9th April was 18,696, showing an increase of 823 over the number sent out in the week ending April 2nd.

The Chancellor's Budget, which was telegraphed by the British Indian Submarine Cable, was published in Bombay the next morning.

The manufacture of the Falmouth, Gibraltar, and Malta Telegraph Company's cable was completed on the 8th ult. The laying operations are to be commenced ,at the Malta end of the route, and are so timed that the Bay of Biscay may be reached during the fine weather which may be expected about the middle of this month. The work of submersion is to be completed by the 31st.

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	s.	d.	To £	s.	d.
COPPER.						
Best selected, per ton	73	0	0	,,	,,	,,
Tough cake and tile do.	71	0	0	72	0	0
Sheathing and sheets do.	75	0	0	,,	,,	,,
Bolts do.	77	0	0	78	,,	,,
Bottoms do.	78	0	0	,,	,,	,,
Old (exchange) do.	63	0	0	,,	,,	,,
Burra Burra do.	74	0	0	,,	,,	,,
Wire, per lb.	0	0	10	,,	,,	,,
Tubes do.	0	0	11	,,	,,	,,
BRASS.						
Sheets, per lb.	0	0	8½	0	0	9
Wire do.	0	0	7½	,,	,,	,,
Tubes do.	0	0	10½	,,	,,	11½
Yellow metal sheath do.	0	0	6½	0	0	6⅞
Sheets do.	0	0	6⅜	,,	,,	,,
SPELTER.						
Foreign on the spot, per ton	19	15	0	20	0	0
Do. to arrive	19	5	0	19	15	0
ZINC.						
In sheets, per ton	24	0	0	,,	,,	,,
TIN.						
English blocks, per ton	136	0	0	,,	,,	,,
Do. bars (in barrels) do.	137	0	0	,,	,,	,,
Do. refined do.	137	0	0	,,	,,	,,
Banca do.	134	0	0	,,	,,	,,
Straits do.	132	0	0	134	0	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	6	6	1	8	0
IX. do. 1st quality do.	1	12	6	1	13	6
IC. do. 2nd quality do.	1	6	0	1	6	6
IX. do. 2nd quality do.	1	12	0	1	12	6
IC. Coke do.	1	3	0	1	3	6
IX. do. do	1	9	0	1	9	6
Canada plates, per ton	13	10	0	14	10	0
Do. at works do.	13	0	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	2	6	7	5	0
Do. to arrive do.	7	5	0	,,	,,	,,
Nail rods do.	7	5	0	7	10	0
Stafford in London do.	8	5	0	9	0	0
Bars do. do.	8	0	0	9	0	0
Hoops do. do.	8	17	6	10	15	0
Sheets, single, do.	9	15	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	0
Bars, common, do.	6	15	0	,,	,,	,,
Do. mrch. Tyne or Tees do.	6	10	0	,,	,,	,,
Do. railway, in Wales, do.	6	12	6	7	0	0
Do. Swedish in London do.	9	15	0	,,	,,	,,
To arrive do.	9	12	6	,,	,,	,,
Pig No. 1 in Clyde do.	2	18	6	3	5	6
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. No. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	10	0	5	15	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pig in London do.	6	0	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	13	10	0	13	15	0
Do. (hammered) do.	14	15	0	,,	,,	,,
Do. in faggots do.	15	15	0	16	0	0
English spring do.	17	0	0	23	0	0
Quicksilver, per bottle	6	17	0	,,	,,	,,
LEAD.						
English pig, common, per ton	18	10	0	18	12	6
Ditto. L.B. do.	18	15	0	,,	,,	,,
Do. W.B. do.	19	0	0	,,	,,	
Do. sheet, do.	19	0	0	19	5	0
Do. red lead do.	20	0	0	20	10	0
Do. white do.	27	0	0	30	0	0
Do. patent shot do.	22	0	0	,,	,,	,,
Spanish do.	18	0	0	,,	,,	,,

*At the works 1s to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

WE HAVE ADOPTED A NEW ARRANGEMENT OF THE PROVISIONAL PROTECTIONS APPLIED FOR BY INVENTORS AT THE GREAT SEAL PATENT OFFICE. IF ANY DIFFICULTY SHOULD ARISE WITH REFERENCE TO THE NAMES, ADDRESSES OR TITLES GIVEN IN THE LIST, THE REQUISITE INFORMATION WILL BE FURNISHED, FREE OF EXPENSE, FROM THE OFFICE, BY ADDRESSING A LETTER, PREPAID, TO THE EDITOR OF "THE ARTIZAN."

DATED MARCH 22nd, 1870.

840 J. Milne—Firegrates
841 R. H. Rimes—Boots
842 W. H. H. Clemesbs and T. Roberts—Self cleansing filters
843 W. Gallimore—Drying yarn or thread in the skein
844 D. Joy—Increasing the efficiency of steam generators
845 W. R. Lake—Slide valves
846 S. S. Turner—Sewing straw
847 J. H. Johnson—Locomotion
848 D. Gray—Wheel tyres
849 T. J. Smith—Treatment of ores
850 C. J. Eyre—Producing motive power

DATED MARCH 23rd, 1870.

851 J. and J. Bradbury and J. Roberts—Felting hat bodies
852 W. T. Culmer—Brushes
853 J. B. Colbran and W. Pollard—Mouse and rat trap
854 C. Farrow and R. B. Jackson—Construction of
855 M. Chapman—Device for containing photographic pictures
856 W. R. Lake—Steel
857 J. Moore—Bungs holes of casks
858 J. C. Cusbion—Picks for dressing marble and other stone
859 J. H. Miles—Velocipedes

DATED MARCH 24th, 1870.

860 S. Mawson—Administration of nitrous oxide gas
861 T. P. Hawksley—Thermometers
862 J. Gilchrist—Ratchet brace
863 H. R. Fossbawe and W. H. Smith—Tanning hides
864 R. H. Kay and A. T. Richardson—Manufacture of crape
865 J. Sawyer and J. Brindley—Furnaces
866 S. Bateman—Measuring card filleting whilst in the process of making
867 G. A. Buchholz—Semolina
868 E. Cambridge—Rollers
869 T. Claridge and J. Jeavons—Armour plates
870 W. R. Lake—Turbine water wheels
871 L. Watson and J. Hall—Registering goods raised in warehouses
872 W. R. Lake—Preparing sulphuric acid for the manufacture of manure

DATED MARCH 25th, 1870.

873 A. Baumann—Steam engines
874 T. Gibb and C. Geltsharp—Smelting copper, and other metals
875 T. Gibb and C. Gelstharp—Extracting copper
876 T. J. Smith—Treatment of sulphurets in order to extract precious metals
877 W. R. Thomson—Fastening the doors of railway carriages
878 E. T. Truman—Preparing gutta percha
879 R. F. M. Harcourt—Fastening railway carriage doors
880 J. J. Cross—Propelling vessels
881 J. Townsend—Obtaining baryta, &c.
882 B. Hunt—Valves
883 A. Dixon—Season tickets
884 C. Jean—Weighing goods
885 W. R. Lake—Valves
886 W. Ramsden, J. C. Pearce, and R. Ayres—Sorting wool

DATED MARCH 26th, 1870.

887 A. Angell—Heating metal bars
888 W. H. Grassam—Horse hoes
889 C. D. Abel—Grinding saws
890 J., C., and G. Watson—Candles
891 T. J. Smith—Regulating the driving of mill-stones
892 A. Dickinson and W. W. de la Rue—Bezique markers
893 J. C. Morgan, H. Macaulay, and F. W. Waide—Register stoves
894 W. Dobson—Cooling liquids
895 W. Bailey—Brewing
896 J. H. Johnson—Extracting moisture from peat and other materials
897 A. H. Melville—Rotary printing machines

DATED MARCH 28th, 1870.

898 J. W. Perkins—Fulminating compounds
899 R. Smith—Winding yarns
900 J. Hopkinson and R. Newton—Spinning fibrous substances
901 J. Sampson and R. Minton—Paint
902 W. Gray and T. Biggin—Metal bushes for casks or barrels
903 S. P. Baker—Locking and unlocking the gates of railways
904 J. H. Johnson—Wrenches
905 A. Nicole—Lever escapements for watches and other time keepers
906 W. R. Lake—Anchors
907 W. E. Newton—Raising water, mud, and other disintegrated substances
908 J. S. Davies and W. E. Yates—Looms
909 O. H. Weed—Washing machine and ironing table

DATED MARCH 29th, 1870.

910 R. G. Rainforth—Consuming smoke
911 W. McNabb—Bale hoops
912 R. Saunders—Rendering water-tight dock gates and like openings
913 F. J. Upton—Hats
914 J. A. Lund—Watch keys
915 A. and F. Wilcock and R. Robinson—Preparing cotton
916 J. Holding, J. Eccles, and W. B. Cooper—Temples employed in looms
917 H. Hughes—Reducing metal rods
918 C. Cotton—Knitted fabrics
919 J. P. Passedoit and L. A. Ritterbandt—Peat charcoal

DATED MARCH 30th, 1870.

920 J. Fennell—Privies
921 T. A. Hickley and W. Utting—Steering ships
922 G. Clark—Heating, cooling, and evaporating liquids
923 H. B. Preston—Evaporating sugar
924 J. Cofield—Fastenings for braces
925 J. Tietjen—Marking press
926 J. Lister—Knives
927 G. Flashman—Mattresses
928 J. H. Johnson—Artificial fuel
929 A. Stiefbold and G. N. Cory—Concertinas and accordions
930 C. Necker—Sewing machines
931 W. Avery—Umbrellas
932 T. J. Smith—Reaping machines
933 J. Sellers—Cutting wood
934 E. Funnell—Railway alarm signal

DATED MARCH 31st, 1870.

935 G. Parsons—Feeding apparatus for carding engines
936 M. Knowles, J. Conlong, and W. Frankland—Looms
937 J. Capper—Chimney tops
938 C. D. Anstin—Lubricators
939 A. B. Reis—Preserving fermented liquors
940 F. Tocher—Ventilation of hats
941 W. McCraw—Photography
942 W. R. Lake—Mechanism for diminishing friction
943 J. H. Johnson—Preparation of soluble phosphates of lime
944 R. Scott and W. McIvor—Treatment of mineral oils
945 J. M. Clark—Soldering tin cases
946 J. N. Taylor—Drawing nails
947 W. B. Quelch—Railway chairs
948 A. V. Newton—Preparing Iceland and Irish moss for use as food
949 G. A. Huddart—Railways
950 J. Bailey—Registering figures applicable to seats of chairs
951 W. R. Mowbray and J. Martin—Protecting goods in railway trucks
952 R. Atkin—Fastenings for jewellery

DATED APRIL 1st, 1870.

953 J. Dribble and S. Raworth—Machines for spinning
954 W. Maclean—Printing
955 F. A. Harrison and C. Priestland—Adjusters for articles of dress
956 C. B. Parkinson and J. Metcalf—Working check straps in looms
957 C. Newhouse—Hoists
958 J. L. de Negroni—Stoppering bottles
959 H. J. Haddon—Pedo-locomotion of the human body
960 A. V. Newton—Sewing machines

DATED MARCH 2nd, 1870.

961 F. Field and G. Siemssen—Illuminating oils and solid hydrocarbons
962 A. Ody—Weighing machines
963 J. Chrimes—Safety and convenience of railway passengers
964 J. Wadsworth—Portable oven
965 H. Law—Measuring fluids
966 H. Jackson—Drying grain
967 H. Jackson—Mills for griading
968 A. Barlow and J. Taylor—Preparing cotton for spinning
969 T. L. Livsey—Starching woven fabrics
970 I. Summersfield and J. G. Sanderson—Pressing machine
971 W. Smith—Working and locking railway signals and switches
972 W. Rowden—Reefing the sails of ships
973 W. E. Newton—Horseshoe and other nails
974 J. R. Cadman—Brackets for shop windows
975 E. Thornton—Heating by the circulation of hot water
976 J. Shackleton—Utilising exhaust steam
977 C. Wilson and J. Peebles—Slide valves
978 H. J. T. Piercy—Tube cutters
979 A. M. Hobson and E. C. Smith—Velocipedes

DATED APRIL 4th, 1870.

980 W. Johnson—Sheet metal saddle trees
981 G. Deadman—Horse hoes
982 W. N. MacCartney—Reducing india rubber
983 J. W. Baker and J. Grange—Kilns
984 F. R. A. Glover—Weighing anchors
985 A. Whitaker and E. Stead—Machinery for spinning yarn
986 A. T. Anquetil—Protecting metallic surfaces from oxidation
987 W. R. Lake—Illuminated clock
988 C. J. Eyre—Securing envelopes

DATED APRIL 5th, 1870.

989 J. Wiuter—Filling bottles
990 H. W. Hammond—Iron
991 H. A. Dufrene—Winding yarns
992 T. Smith—Looms
993 J. Pickup—Spinning and twisting fibres
994 A. M. Clark—Treating pulps
995 J. Pickering—Forming holes in iron castings
996 J. Mors and W. L. G. Wright—Projecting liquids
997 T. Rose and R. Emerson—Utilising materials obtained in treating cotton seed
998 C. J. Busk—Preparing cement
999 E. Green—Removing deposits from steam boiler flues
1000 J. Parker—Dry earth closets

DATED APRIL 6th, 1870.

1001 E. Lever—Name plates in connection with letter boxes
1002 J. and W. McNaught—Furnaces for economising fuel
1003 D. M. Childs—Sash fasteners
1004 T. Horridge—Communication between guards and passengers
1005 T. Ford—Gas lamps
1006 I. Baggs—Carbonates of ammonia
1007 F. J. Hill—Depositing parcels
1008 A. H. Brandon—Strap fastener
1009 R. Jones—Preservation of substances to be used as food
1010 J. Mayer—Specula for surgical purposes
1011 J. Sharrock—Winding engines
1012 F. J. Sweeting—Indicating distance travelled by vehicles
1013 G. H. and J. James—Cigar cases
1014 W. Young and P. Brash—Gas
1015 C. H. Wight—Stationery stand and combined thermometer
1016 C. H. Wight—Inkstand
1017 W. T. Henley and D. Spill—Non-explosive compounds

DATED APRIL 7th, 1870.

1018 A. B. Brown—Steering gear
1019 M. J. Roberts—Propelling ships
1020 C. and T. Crossley and R. Whipp—Making size
1021 T. Adams—Clip file
1022 T. Adams—Binding papers
1023 H. A. Bonneville—Obtaining the true time at any moment
1024 L. A. Brode—Obtaining fibre suitable for paper making
1025 C. H. Gardner and G. H. Carey—Printing machines
1026 C. Montague—Overcoats
1027 J. Shackleton—Warming rooms
1028 T. Robinson—Skimming cast iron during the process of casting
1029 C. Clinch—Cleansing beer
1030 E. Daniel—Indicating the water level in steam boilers
1031 F. Taylor—Paper collars

DATED APRIL 8th, 1870.

1032 A. Watkins and R. C. Hanrott—Winding and setting watches
1033 J., W., and F. W. Edmondson—Engraving cylinders
1034 W. H. Carson and J. V. Toone—Automatic lamb creep
1035 H. J. Kirkman—Pianofortes
1036 G. Baker—Nails
1037 T. Aveling—Portable engines
1038 C. F. Anderson—Cleaning windows
1039 A. Etienne—Velocipedes
1040 W. Cooper—Sliver or cotton cans
1041 J. B. Blythe—Preserving wood
1042 J. Fairclough—Millstone dress
1043 A. Craig—Pulverising minerals and other substances
1044 C. F. Varley—Telegraphs

DATED APRIL 9th 1870.

1045 W. Nelson—Figured fabrics
1046 H. Mallet and C. Russell—Lace machines
1047 W. E. Newton—Machinery applicable for inland navigation
1048 A. H. Brandon—Looms
1049 A. Mosley—Jacquards
1050 P. C. Thamsen—Finishing linen
1051 J. Henderson—Wrought iron
1052 W. R. Lake—Steam vessels
1053 A. Parkes—Steel
1054 S. C. Lister—Looms
1055 L. Weber—Galvanic batteries

DATED APRIL 11th, 1870.

1056 G. H. Ellis—Rotary engines
1057 W. Higgins—Carriage lamps
1058 A. Brown—Fancy boxes
1059 J. B. Booth—Lubricating spindles
1060 R. Adams—Spring hinges
1061 T. J. Smith—Treating excremental matters

DATED APRIL 12th, 1870.

1062 C. H. Newman—Unintoxicating and unfermented malt liquor
1063 R. Wilson—Steam engines
1064 C. C. and W. T. Walker—Centre valves for gas purifiers
1065 T. Turner—Bricks
1066 W. B. Haigh—Vertical saw frames
1067 L. W. Thomas—Fireplaces
1068 I. Adams—Treatment of metal surfaces
1069 J. Kirk, S. Shelmedine, and C. Froggatt—Planking the bodies of hats
1070 J. Howard—Ploughs
1072 M. Henry—Telegraphic apparatus
1073 W. R. Lake—Railway brakes
1074 W. R. Lake—Whiffle trees
1075 W. S. Coon—Applying power to the running of machinery and tools
1076 G. A. J. Schutt—Yarns
1077 B. Baugh and B. Walters—Attaching knobs to doors
1078 E. Lord—Preparing cotton

DATED APRIL 13th, 1870.

1079 E. Wesre—Using the waste threaks of carding engines
1080 W. Angus—Masthead and other blocks
1081 M. Bailey and W. J. Armond—Spinning and doubling
1082 C. Joseph—Filters
1083 W. Spence—Shaping staves for casks
1084 A. V. Newton—Working railway switches
1085 C. Hamilton—Rendering bedsteads available as escapes in case of fire
1086 R. M. Marchant—Perpetual motion
1087 J. Philipson—Carriage windows
1088 F. W. Brooksbank—Lace
1089 W. R. Lake—Utilising cotton waste
1090 F. Pattison—Metal-founders' blacking
1091 T. Dale—Extinguishing fires

DATED APRIL 14th, 1870.

1092 A. Taylor—Guns
1093 W. R. Lake—Looms
1094 J. Plaskitt—Velocipedes
1095 L. Stewart—Wheels for carriages, waggons, and other vehicles
1096 W. Jesty—Coating the bottoms of ships
1097 G. Spruce—Forming patterns on floor coverings
1098 W. Simpson and A. A. Gardner—Steam engines
1099 R. J. Everett—Utilising waste products
1100 A. V. Newton—Production of metallic alloys of manganese
1101 W. R. Lake—Knitting machines
1102 A. A. Wilbaux—Engraving
1103 P. N. J. Macabies—Water feeding apparatus for boilers
1104 W. R. Lake—Boring rocks
1105 W. Cotton—Knitted fabrics
1106 C. Beard—Partitions or walls
1107 E. de la Rue—Croquet mallets
1108 E. P. Sheldon—Water meters

DATED APRIL 16th, 1870.

1109 H. Brooks—Construction of receptacles for containing liquids
1110 T. White—Dish covers
1111 I. Baggs—White lead
1112 T. Dickins—Spinning silk and other fibrous substances
1113 A. Borgnet—Retorts
1114 H. E. Newton—Gymnastic exercises
1115 J. Craven—Raising and lowering heavy bodies
1116 T. Wood—Omnibuses—and indicating the number of persons entering therein
1117 N. Murphy—Securing the duty upon spirits in distilleries
1118 A. L. Dowie—Treating copper, zinc, and their compounds
1119 F. J. X. Gunther and J. J. A. C. de Latouche—Revolvers
1120 J. L. Norton—Furrowing millstones

DATED APRIL 18th, 1870.

1122 J. Barrow—Napthalene
1123 P. Toepler—Cleaning wool
1124 J. Townsend—Applying heat
1125 A. M. Stratbern and D. G. Morrison—Safety apparatus for steam engines
1126 W. F. Murray and T. D. McFarlane—Shaping plastic materials
1127 T. McIsaac—Folding bed table
1128 W. Spence—Hats
1129 G. C. Cooke—Recording numbers

DATED APRIL 19th, 1870.

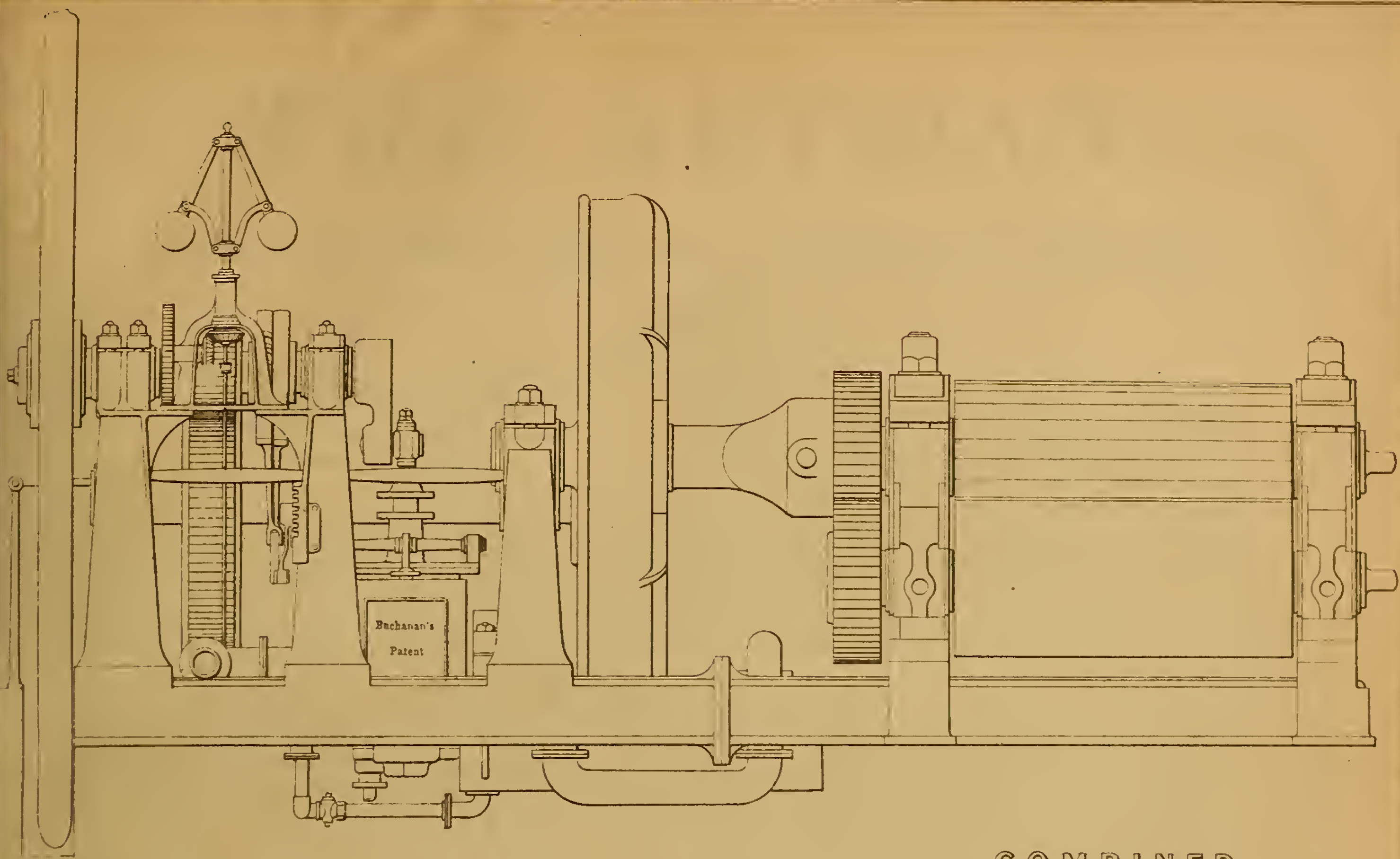
1130 H. B. Barlow—Door locks
1131 J. F. Spencer—Steam engines
1132 S. Barton—Garden hose
1133 F. Tallis—Gas cocks
1134 R. Cherry—Looms for weaving
1135 B. J. B. Mills—Buttons
1136 S. C. Lister—Weaving velvet
1137 D. Forbes—Treatment of sewage
1138 P. Hoyle—Gold leaf
1139 M. Nolden—Curing mealy stuffs
1140 D. Sowden and R. C. Stevenson—Turning wood or metal
1141 W. Brown—Plummer blocks
1142 H. W. Hammond—Superphosphate of lime
1143 W. R. Lake—Cartridges for breech loading firearms
1144 G. Symes and J. W. Young—Manufacture of gas
1145 A. V. Newton—Operating the throttle valve in locomotives
1146 C. Cooke—combination of articles for culinary purposes
1147 J. G. Jones—Slide valves
1148 E. B. Sampson—Feeding machinery

DATED APRIL 20th, 1870.

1149 J. Green—Coke
1150 W. Smith—Looms for weaving
1151 W. and C. S. Catt—Carriage wheels
1152 W. R. Lake—Steam condensers
1153 R. Sinclair—Locomotive boilers
1154 W. R. Lake—Reversible butt hinges
1155 J. H. Johnson—Hardening composition
1156 W. Batebelor—Firebars
1157 R. P. Beattie—Valve cock
1158 A. M. Clark—Shirt fronts and cuffs
1159 G. W. Ley—Imitation of carving in wood and other materials

DATED APRIL 21st, 1870.

1160 R. F. Bigot—Apparatus combining the functions of a bung and vent peg
1161 W. A. Oatey—Reaping machines
1162 J. Milton—Yarn holders
1163 M. C. Haull—Heating stoves
1164 A. V. Newton—Adjustable bedstead
1165 J. H. Johnson—Mowing machines and sharpening the cutters of the same
1166 J. T. Sheppard—Cutting sole pieces or other forms of leather
1167 T. Bell—Treating calcined pyrites for the better utilisation thereof



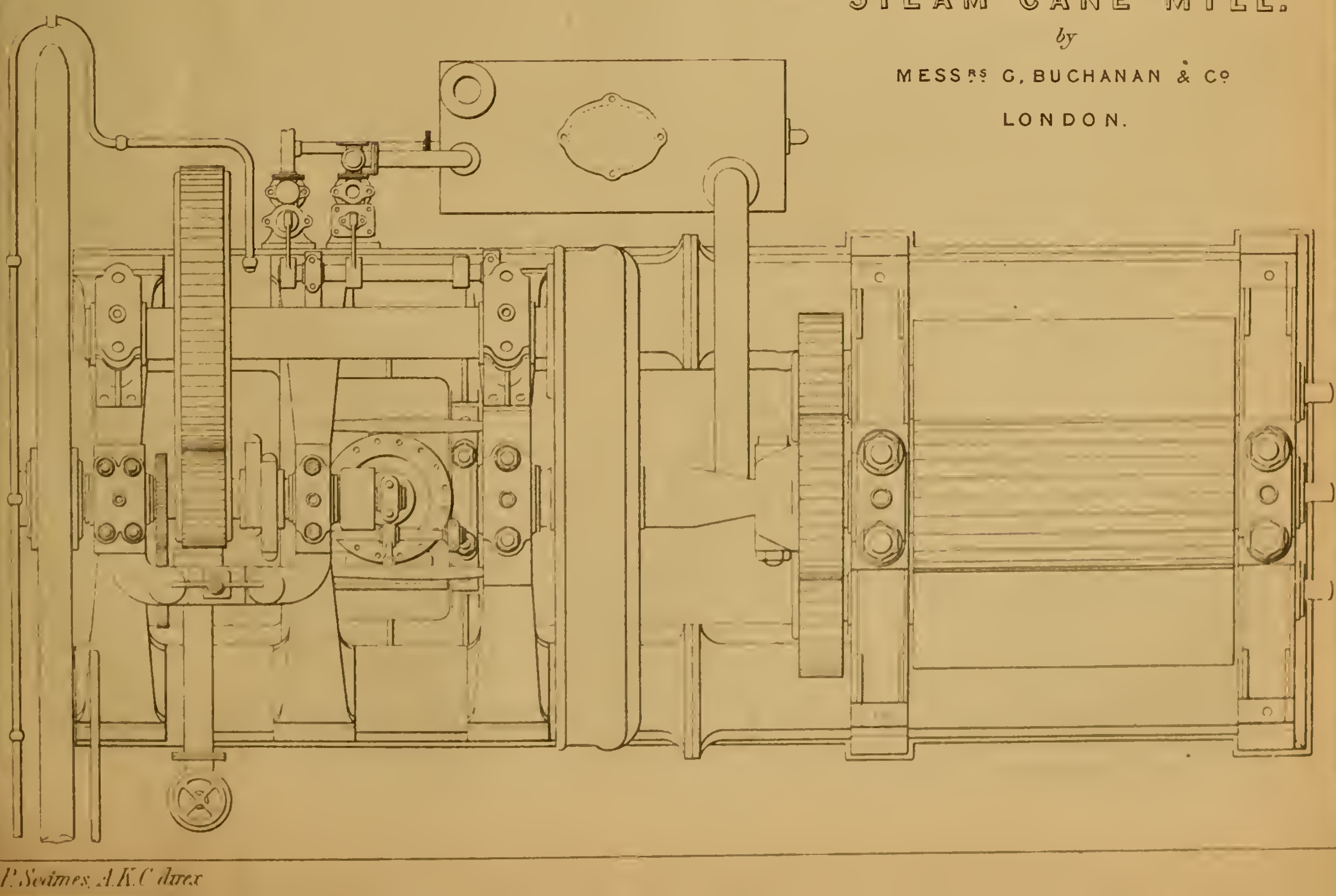
COMBINED

STEAM CANE MILL.

by

MESSRS G. BUCHANAN & Co

LONDON.



P. Seimes, A.K.C. direx

THE ARTIZAN.

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1st. JUNE, 1870.

COMBINED STEAM CANE MILL.

By Messrs. G. Buchanan and Co., London.

(*Illustrated by Plate* 361).

The reduction in the sugar duties, effected by Mr. Lowe, the Chancellor of the Exchequer, is so far favourable to the sugar grower as to call for a few remarks concerning its manufacture in the tropics. It is, no doubt, well known to our readers, that since the abolition of slavery in the British Colonies, the legislation upon this subject has been so disastrous to their welfare that not only the twenty millions sterling of compensation, but the entire capital of the planters, representing a sum largely in excess of that amount, have both been sunk in the vain endeavour to continue in a race where they were so unmercifully handicapped. Had such legislation the excuse that it was enacted in the sacred cause of the abolition of slavery it could not be objected to, however ruinous to our own colonies, but when it is considered that slave-grown sugar from foreign countries was admitted upon precisely the same terms as the sugar grown in the emancipated British West India Islands, it is evident that a desire for the total abolition of slavery was the last thing that could have been considered. Nothing, in fact, has tended to foster slavery during the last five and thirty years more than the encouragement of slave-grown sugar by the British Government. The extorting a promise from Spain that she would at some future time abolish slavery, and at the same time showing her how, by the continuance of slavery, enormous profits could be made, was, when we consider the character of the people, the height of absurdity; while to crown all it was gravely stated that such admission of slave-grown sugar was in the interests of free trade. It can scarcely be doubted that had slavery in foreign countries been discountenanced in the only way in which it could be felt, viz., by taxing its produce, it would long since have ceased to exist, and in all probability the late American war and present Cuban insurrection would have been averted.

The foregoing remarks would be sufficient to account, to a large extent, for the want of energy exhibited generally throughout the West Indies, but in order to account for the chronic depression of sugar growing throughout the entire British possessions another cause must be discovered. This is easily done in the so-called differential duties, whereby the concentrated cane juice, naturally pure and quite as easily made into good as into bad sugar, was until lately practically prohibited from appearing in any other form but the latter. Sugar had absolutely to be manufactured down to a certain quality of *badness* to pay; it, therefore, cannot be a matter of surprise if the manufacturers were careless about effecting improvements. Now, however, the case is altered, for although the taxation is upon the same pernicious principle, the amount of wrong is so far reduced as to encourage sugar growers to manufacture sugar of a high quality, and it is with a view to their assistance that the following remarks are submitted.

It is an old saying amongst planters, that sugar is made in the field, but, though we may at a future period have something to say with respect to the machinery which might in certain circumstances be advantageously employed for the purposes of cultivation, we will at present confine ourselves to the processes of sugar making after the cane has arrived at maturity, beginning, as a natural consequence, with the extraction of the juice from the cane.

There have been a variety of schemes for effecting this purpose, such, for instance, as extraction by diffusion, or the extraction of the saccharine matter from the cane by dissolving it out by means of hot water; but as this process necessarily entails the subsequent evaporation of an enormous quantity of water and consequent expenditure of a proportionate amount of fuel, it is inapplicable where fuel is dear, which is the case with almost every cane-growing district in the world. Another scheme, invented by the fertile genius of Mr. Bessemer, consisted of a long rectangular box in which a plunger, or piston, worked backwards and forwards for a portion of its length. The canes were fed in through holes in the top of the box, and dropping down to the bottom during the absence of the plunger, were cut off in lengths equal to the depth of the case by its return stroke. The canes after being thus cut in lengths were forced along to that part of the box beyond the travel of the plunger, and as the process continued fresh lengths of cane were carried forward until that portion of the box was full. This box was open at the end, but slightly tapered, and it was expected that the natural stiffness of the canes, combined with the taper of the box, would jam them up sufficiently close as to squeeze out the juice through holes provided along the bottom. When experimented upon in England with old, woody canes brought, we believe, from Madeira, it appeared to fulfil the idea of its inventor, as the toughness and hardness of such canes formed sufficient resistance to obtain the desired pressure. When, however, we tried it in the West Indies, with large fresh canes, it was found impossible to obtain the required resistance, although several modifications in the form of the end of the end of the box were made; and, consequently its use was discontinued.

The origin of the system of expressing the juice from canes by passing them between rollers must be attributed to the Chinese, and, as is generally the case with the Celestials, it appears, so far as we can judge, that they have not altered their first pattern up to the present date. The Chinese mill is entirely constructed of hard wood, and consists of two vertical rollers, each about 4ft. diameter and 3ft. high, geared together by means of wooden cogs and worked by cattle, without the intervention of any multiplying gear. By means of a mill of this description, a sufficient quantity of canes to make about two tons of sugar per week can be ground, while, in consequence of the roller gudgeons and bearings being made of wood, they can be heard when at work for a distance of more than a mile. The mills first erected in our colonies were similar to these Chinese mills, though scarcely so effective, as the rollers were considerably less in diameter. These, however, soon gave place to mills with horizontal rollers driven with multiplying gear, which not only gave a better surface speed to the rollers, but obviated the unequal wear of their surface; many of these mills are still in use in very small estates.

Passing over the sugar-cane mills driven by wind or water, as being suitable only to peculiar situations, we come at once to the steam cane mill, which in one form or another has now become almost universal. As, however, want of space would make it utterly impossible to give a description of the different forms of steam cane mills that have at various times been designed, or even of such are still in existence, we will begin with one which appears to us to combine a greater number of improvements than any other with which we are acquainted. This mill is illustrated in Plate 361, where an elevation and a plan are shown of the engine and mill complete, an arrangement which was patented a few years ago by Mr. G. Buchanan of 25, Bucklersbury, London. Upon reference to the Plate (361), it will be seen that the engine and mill stand upon the same bed-plate, and although for convenience of carriage this bed-plate is not usually cast in one piece, there is of course no difficulty in making it as strong as if it had been cast whole. The object of this arrangement is two-fold, viz., to obviate the expense of an elaborate foundation and to prevent the machinery being set up, or afterwards becoming, "out of truth." The importance of these considerations will be obvious when it is remembered that in nearly all the places where sugar mills are required, skilled labour is enormously expensive. But in order to line out and construct separate massive foundations for the engine, the intermediate gearing and the mill, not only a large amount of material but a considerable amount of skill is required; while the erection of the machinery upon those foundations can only be performed with the assistance of an engineer. Again, unless very great care has been bestowed, and unless the ground is favourable for the purpose—a circumstance that is very unusual in cane-growing districts—a very few day's work will suffice to throw the whole of the shafting and gearing out of truth, as the multiplying power brings an enormous strain upon the intermediate gearing. The additional friction, and consequent loss of power, produced by a comparatively trifling settlement of the foundations is enormous, besides which, the unequal strain upon the teeth of the wheels is very apt to break them. In *combined* cane mills, or in other words, in mills where engine, intermediate shafting, and the mill are all upon one bed plate, no expensive foundation is needed. The bed-plate itself forms the foundation, and all that is requisite is to place it level upon the ground. When this is done the various parts of the machinery have simply to be fixed in their proper places. It is most important that every mill when erected in this country should have the position of every separate part most distinctly marked, in order to facilitate erection; when this is properly done, its erection abroad is perfectly simple, and as no adjustment is required, a very few days will suffice to put it together ready for working. Another advantage possessed by mills of this description may be mentioned, viz., that being independent of any foundation they can be removed and erected in any other position at a comparatively small outlay.

The advantages of having the mill and engine upon the same bed-plate have for many years been so fully recognised, that numerous designs for effecting this purpose have from time to time appeared. The principal objections made to the combined system were, that the entire mill was liable to vibrate or oscillate when at work, in consequence of the excessive height of the machinery above the bed-plate, which characterised most of these arrangements; and also that the bearings and other working parts were difficult of access, resulting from the limited space afforded by the bed-plate. A few years ago, however, these difficulties were overcome by Mr. G. Buchanan, who invented the arrangement shown in Plate 361. Here it will be seen that by the adoption of an oscillating engine and by placing the fly-wheel outside the bed-plate, the entire machinery is kept low down; while at the same time this position of the fly-wheel, together with the arrangement of the gearing, afford easy access to all the working parts. It will be seen that the top roller of the mill is driven by internal spur gearing; this plan we consider to be very good, as it gives enormous strength just where it is needed.

Various plans have been attempted for making the cast-iron side frames of the mill to safely withstand the sudden violent strains to which they are constantly subjected, without inconveniently increasing their weight; as it must be remembered that in most sugar-growing countries the difficulty and expense of the carriage of heavy pieces of machinery is very considerable. In some instances attempts have been made to reduce these strains by the substitution of compound levers or springs in the place of bolts, for the purpose of keeping down the top roller, but it has been found that although these contrivances do, to a certain amount, effect their object, the canes are liable to pass through the mill without being sufficiently pressed. The substitution of wrought for cast-iron is evidently the only way in which this difficulty can be overcome, but as a solid wrought-iron framing would be enormously expensive, Mr. Buchanan designed, about ten years ago, a side frame composed partly of cast and partly of wrought-iron. The method by which he effected this object was by making a species of skeleton framing of cast-iron, with cores through it for the reception of the requisite bolts, and fitting a strong wrought-iron cheek to each side of the exact outline of the framing, and then firmly riveting the whole together. By this means a much lighter frame was obtained, with a considerable increase of strength; so much so indeed, that we never heard of a side frame upon this construction being broken.

(*To be continued.*)

BROWN'S PATENT TUBE-STOPPER.

The following description, extracted from the *American Artizan*, of a tube-stopper, will, we think, be of use to many of our readers:—

The accompanying engravings represent an improved stopper applicable to locomotive boiler-tubes, condenser-tubes, and the like, when for any reason the use of such an appliance becomes desirable. Fig. 1 is a side view, and Fig. 2 a longitudinal sectional view of the device.

A indicates a screw-bolt, the head, *a*, of which, in applying the stopper, occupies a position within the mouth of the tube to be stopped. The opposite end (*b*) of such bolt is formed with a square portion to provide for the application of a wrench to keep the bolt from turning while the nut, C, is being screwed up or slackened as the case may be.

Fitted upon the bolt, between its head, *a*, and the nut, C, are two cones or truncated parts, D, arranged with their smaller or truncated ends to face each other, and so that they fit within a packing ring made of lead or other suitable material, which ring is shown at E. Within this ring and between the cones, D, is a space or chamber which is filled with red-lead cement or equivalent substance.

FIG. 1.

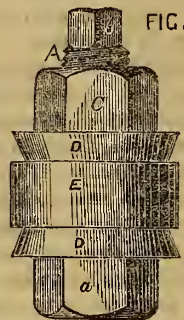
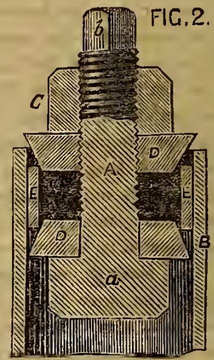


FIG. 2.



The outer one of the cones, D, should be arranged to move freely on the bolt under the action of the nut, C, while the inner cone takes its bearing against the head, *a*, of the bolt.

By screwing up the nut, C, the ring, E, is expanded by the action of the cones, D, on the opposite sides of it, so as to stop the tube, the closing of which is rendered all the more effectual by the cones, as their truncated ends approach each other, being caused to force out through the joints between themselves and the ring, E, a portion of the cement contained within the latter, as previously explained.

When the device is used for stopping the tubes of condensers, or other tubes not exposed to a high heat or steam pressure, the ring, E, may be made of lead or similar metal easily acted upon by pressure, and in this case may be formed continuous or without division at any point. When, however, the stopper is to be applied to the tubes of steam boilers, or other tubes exposed to a high degree of heat, then the ring should be of harder or less fusible metal, and should be split or divided, as packing rings for other purposes have been made, such joint or split preferably not being in a direct or straight line with the tube, or in lieu of this, two rings may be used with straight divisions arranged to break joints.

PROPOSALS FOR THE ILLUMINATION OF BEACONS AND BUOYS.

By Thomas Stevenson, F.R.S.E., &c.

An exceedingly interesting pamphlet upon the illumination of beacons and buoys has just been written by Mr. Stevenson, the well-known lighthouse engineer, and author of several treatises upon kindred subjects, and as the object in view is of such vast importance, being no less than the saving of life and property, we propose to lay before our readers some of his "proposals." The author begins by saying:—

"The first practicable proposal to increase the efficiency of uninhabited beacons was in 1851, when I introduced what was called the Apparent or Borrowed Light, at the entrance of Stornoway Bay, in the island of Lewis It was originally proposed to place the lighthouse tower upon the Arnish Rock, a small reef at the entrance of the bay, 530ft. from the shore, submerged by every tide, and exposed to a heavy run of sea. The expense of carrying out such a scheme precluded all idea of its adoption, and the lighthouse was accordingly erected on the mainland by the Northern Lights Commission.

"In order, however, to point out by night the position of the rock, the following expedient was employed:—A powerful beam of parallel rays was projected from a window in the tower, upon an iron beacon, which was erected on the Arnish Rock, where it was received by optical agents calculated to redistribute the light in the required directions. Fig. 1 shows a pictorial view of this mode of distinction, and fig. 2 represents a middle section of the apparatus on the beacon. In this diagram *r r* represent the parallel rays proceeding from the lighthouse on shore; A A, a plane mirror on the beacon which reflects these upon B B, a refracting cylindrical panel of glass, which again causes them to converge in the horizontal, but not in vertical plane, to the principal focus F, whence they finally diverge seawards over an angle of 62° in azimuth. In 1860 the light was farther strengthened by the addition of another lantern, placed above the first, in which was a single mirror, curved so as to produce, without the use of a refractor, the required divergence of 62° in azimuth.

This beacon light, after the lapse of more than eighteen years, still continues to give satisfaction to seamen, to whom the light has all the appearance of coming from a lamp placed on the beacon itself. Other forms of lighthouse apparatus lately introduced could, in such a case as Stornoway, be employed with very great advantage. In 1869 a new form of prism was introduced at Lochindaal lighthouse in Islay, Argyllshire. The Lochindaal prisms, in connection with those of the ordinary form, possess the property, by two refractions and one total reflection, of parallelising the light, by by single agency, even as far back as 180 degrees. A simple modification of those prisms renders them very appropriate for apparent lights. Straight prisms, having the same horizontal section as those at Lochindaal, can be applied so as to cause the beam of parallel rays at once to diverge in azimuth over the seaward arc of 62°. Such prisms are represented in figs. 3, 4,, in which fig. 3, presents an elevation, and fig. 4 a horizontal cross section. In this diagram R R show the parallel rays coming from the shore, incident upon straight panels, *p p*, of the same section as Fresnel's, and upon P P of the new section, by both of which they are converged upon F, and afterwards diverge in azimuth.

Fig. 1.

Fig. 2.

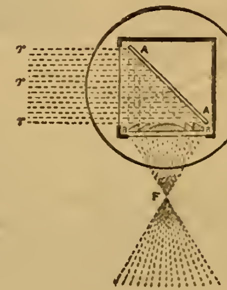
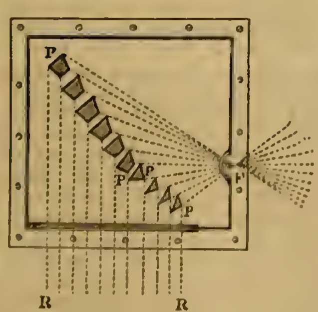


Fig. 3.

Fig. 4.



"The only other existing example of an apparent light is that at the harbour of Odessa, in the Black Sea, which was constructed in 1866 for the Russian Government by Messrs. Chance and Co., of Birmingham. It is entirely dioptric, and is situate 300ft. from the shore.

"The great object to be attained for increasing the power of apparent lights is the condensation of the rays. Were it possible to produce a flame which was so small as to have no sensible divergence after passing through the apparatus on the shore, the best economic effect would be secured. For such a purpose, therefore, the electric light, from its small size, is singularly appropriate. Where this powerful source of illumination cannot be had, the largest size of apparatus at the shore should be employed. At Stornoway a single Argand flame is used in connection with a first order annular lens, but of course all the rays which escape being parallelised by the lens are lost. This loss could to a great extent be saved by the the employment of a large complete holophote, but the cost of this instrument on such a scale would be very great.

"With the hope of reducing the cost of holophotes, I propose, instead of constructing them of glass prisms or silver plate, to revive the old form of paraboloid, consisting of facets of ordinary silvered glass, but instead of making them of very small size and plane, they may be somewhat increased in size and bent, or ground and polished on both faces to curves osculating the parabola. If the edges of these facets were fixed together by Canada balsam—a substance which has nearly the same index of refraction as plate glass—the large loss of light, which has hitherto taken place at every edge of each facet, will be in great measure saved. There will not, as hitherto, be any refraction of the rays of light passing through the edges, and thus the whole will become practically *monodioptric;* or, in other words, will be optically the same as if the paraboloid had been cast of one whole sheet of glass.* It would further be a great improvement to select different points in the flame, for the foci of the paraboloidal facets, so as to secure the useful destination of all the rays. Metallic paraboloids would also be improved if made in two pieces, the upper and lower having different foci.

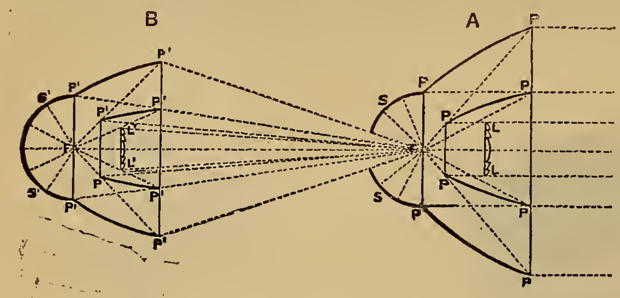
"The density of the flame may also be increased by causing the rays of other auxiliary flames to converge to it, as was proposed by Brewster, who gave two designs, the one catoptric and the other dioptric, for effecting this end. (See "Edin. Trans." vol. xxiv., 1866.) In his catoptric design, all the light which escaped past the lips of the reflector was lost; while in the dioptric, none of the light was saved, except the small cones which fell upon the lenses. Such arrangements were, therefore, far from being holophotal, and he states, indeed, that "the holophote principle is inapplicable' to such a purpose. It is quite true that, besides the waste of light from employing agents that are not needed, his arrangement for parallelising diverging rays could not effect the purpose; but by adopting the true holophotal principle, and abolishing those unnecessary agents, the problem is easily solved. Fig. 5 represents a method by which all the rays from one or more flames may be accurately converged (less loss by divergence, &c.) to the original primary flame. In the paraboloidal holophote marked A, all the rays proceeding from the primary flame are directly parallelised and sent forward upon the distant beacon by the lens L, the the paraboloidal strips P, and the spherical mirror S, with the exception of the small cone P′ F P′, which extends backwards, but is finally returned to F after being acted upon by the ellipsoidal holophote B, in which F′ is an auxiliary flame, L′ a lens having its conjugate foci in F′ and F, ellipsoidal

* Apparatus of this kind will be very suitable for harbour lights, if the economy in construction prove to be considerable, and if the facets could be ground to other curves than the parabola and circle where lateral divergence was wanted. Where lights are coloured, the saving of one superficial reflection will be easily effected by cementing the coloured glass on the refracting or reflecting faces of the lenses or prisms, one face of which may be left rough, which will not only reduce the cost, but give a better surface for the Canada balsam, while the passage of the light will in no way be interfered with.

strips P′ having their foci in F′ and F, and lastly, a spherical mirror S′. All the rays proceeding from the auxiliary flame F′ are therefore converged in a dense cone to F, which is at once the centre of the mirror S, the conjugate focus of the lens L′, the principal focus of the lens L, one of the foci common to the ellipsoids P′, and lastly, the common focus of the paraboloids P. This apparatus, which can, of course, be constructed entirely of glass, may be applied to any number of auxiliary flames placed in line behind each other, all the rays from which will be ultimately parallelised in union with those from the original flame F.

"Before leaving this branch of the subject, I may just state that where buoys have to be illuminated, straight cylindrical glass prisms, inverted conoidal reflectors, or the covering of the buoy itself with some reflecting material, are worthy of being tried.

Fig. 5.

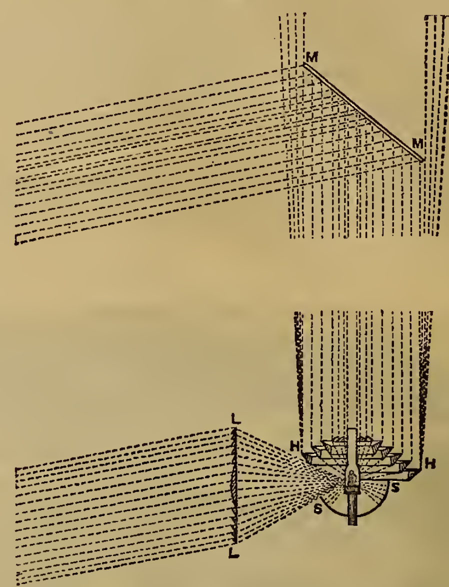


After describing a dipping light for showing the position of the sunken rocks, as illustrated in Fig. 6, Mr. Stevenson says:—

The practical objection to the dipping light is its too great divergence; for it is not desirable that the light should extend farther than a certain limited distance round the point of danger. If, for example, a small-sized holophote had its axial beam directed seawards of the reef, so as to throw the strongest light on that point, the base of the diverging cone would cover many miles of sea, unless the apparatus had a great dip, which could only be when the tower is very much elevated, or the danger very close to the shore. No doubt the small divergence of the electric light would greatly lessen this evil; but there are not many situations where such a mode of illumination is likely to be provided.

"It is possible, however, to reduce the divergence of an ordinary flame to any required amount by means of the following device, which has occurred to me as one of easy application, while it sends the best of the light to the required spot:—Let us suppose a case where the necessary amount of divergence would be given by a small Argand burner, placed exfocally in the vertical plane behind a first-class annular lens. The emergent rays, having thus the required dip, would be thrown directly upon that portion of the sea which was to be illuminated. But all the rays which escaped past the edges of the lens would still be still be lost. Fig. 7 represents an arrangement for making the apparatus holophotal.* If the lens and lamp be placed in a window at a given level in the lighthouse tower, the rays that would otherwise escape are parallelised, and sent upwards by the spherical mirror S (Fig. 7), placed below, and the holophote H placed above the flame, with its axis vertical. The plane mirror M of given dimensions is fixed opposite another window of the tower, at such a height as to intercept that portion of the rays only, which has the required divergence. This cone of light is, by means of the adjustment of the mirror M to the necessary angle of reflection, sent downward

Fig. 7.



to the point of danger, so as to reinforce the rays from the annular lens. In this way the rays which are too divergent are wholly separated from the others, and allowed to escape, and the required area of sea, is alone illuminated. It is obvious that in each case the distance of the mirror from the holophote will be proportional to the required divergence. When this distance is greater than the height of the tower, the mirror might, at land stations at least, where there is no want of room, be fixed at the proper distance, the axis of the holophote being horizontal.

Fig 6.

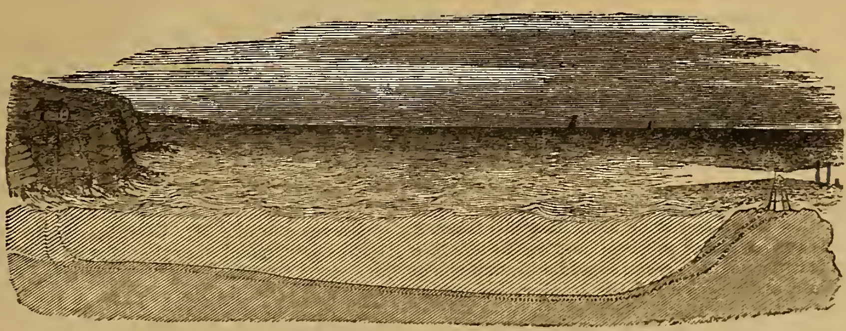
The author then goes on to discuss the practicability of substituting a real for a borrowed light, and describes the various attempts made by him to illuminate a beacon by means of electricity, as shown in Fig. 8; but in spite of numerous experiments and the assistance of such eminent men as Professor Swan, Mr. Hart, Mr. Siemens, Professor Tait, and others, the system does not appear to be as yet perfectly reliable. Mr. Stevenson, however, does not despair, as he says:—

"Whatever obstacles may be found to the application of this scheme, it is natural to suppose that these will be most difficult to overcome in the case of floating buoys, which are moored at sea, and exposed to every alternation of tide and every vicissitude of storm. I am disposed to think, however, that such difficulties may to a large extent be overcome by the substitution of covered boats for the small conical buoys in present use. If floating bodies of this kind were moored to bridle-chains, so as to limit the amount of their swing under the action of wave and tide, it is probable that it would be quite practicable to pass the electric cable through a central aperture or chamber. In order to allow for lateral deviation, a certain amount of play could be provided for, by passing over a horizontal drum,

* To prevent confusion, in the diagram, the diverging rays from the edge only of the holophote are shown.

the slack of the cable, to the end of which a weight would be attached. The weight would descend, or be drawn up over the drum, according as the distance of the buoy from its moorings was decreased or increased. The optical apparatus, hung in gymbals to preserve its verticality, and protected by a lantern, would be placed on deck, with the induction-coils underneath; and in some such way as this, the light might probably be maintained."

Fig. 8.



Mr. Stevenson afterwards discusses the merits of gas as an illuminating medium, but as he very justly observes unless, as is rarely the case, the shore end of the pipe is the lowest, an accumulation of water in it would be a fatal objection.

PATENT LAW.

The Bovill Litigation.

(*Continued from page* 107.)

"Mr. Justice Byles: Here it is, "I do not remember whether I was examined in Keyworth and Seely's case as to the Scotch patent, I do not know whether I said in Bovill *v.* Keyworth that the invention was new." But it does appear that he was called as a witness for Mr. Bovill, and as I understand, in Bovill *v.* Keyworth, the goodness of this patent was under consideration. That does not reflect at all, as it seems to me, upon Mr. Bramwell's uprightness as a witness, because he may be possessed of greater knowledge now than he was possessed of then; but certain it is that he, upon a former occasion, came to give evidence the effect of which was directly contrary to what he gave upon this occasion.

"Mr. Webster: The question in that case was the combination.

"Mr. Grove: That will appear by the judgment.

"Mr. Justice Byles: I know, but he said the specification was new. Gentlemen, I have particularly guarded myself from making any reflection upon Mr. Bramwell. None ought to be made, or were intended to be made by me. There may have been, besides what I have pointed out, the distinction pointed out by my learned friend Mr. Webster. Still that observation he is liable to. Then they call a gentleman of the name of King, who goes through pretty much the same evidence, relating also to the experiments and to the alleged infringements in some other places to which your attention has been fully called by the learned counsel on both sides, and I do not propose to go through it, although I shall allude to it when I come to deal with the alleged infringements.

"Then Mr. Mather is called with respect to what took place at Isleworth, and I think we now come to the general nature of the defendant's evidence as to the anticipation. I now come to a part of the case on which I shall trust you, to a great extent, to remember what you have heard from the witnesses and what you have heard from the learned counsel on both sides. If you wish me to read over this evidence to you in detail, I am perfectly ready to do so; but unless you do wish it, I shall call your attention to what has been said by Mr. Webster, and to what has been said by Mr. Grove, and you will deal with those cases. I will only say a few words upon each of them. I told you long ago that my summing up would be short, and you would therefore be rewarded for the attention which you have paid to counsel. Now there is a great deal of evidence about the Isleworth mill, and what was done there. Many witnesses for the defendant, including Mr. Mather. Evidence was given by Mather, by Rayment, by Shepherd, by Kimmins, by Warren, and by Mr. Podger.

"Now the first observation which I think is to be made on this evidence is, that there is here no anticipation of the plennum so far as I understand the evidence. If I am wrong in that, I shall be happy to be corrected by the learned counsel. What it does tend to show, or is produced to show, as I understand it, is rather with reference to the second and third claim, with respect to the chambers. Now, passing by all *minutiæ* with respect to that, and all questions of time, as I understand the evidence, from the mill cases there was led, but without any regard to plenum, by an exhaust into a chamber or chambers, meal and stive. There was no regulation of the blast, no anticipation of that regulated blast, which is the essence of the second claim. But there was a chamber, and a chamber at one time separated with cloth or bunting, or matting, or something of that kind. It is very material to observe that this was afterwards changed for a boarded chamber. That is upon the defendant's evidence. Now nothing is more unlike that (pointing to the model "G. H. B.") than a boarded chamber. If this be any anticipation, it is by the porous matting which was in the chamber before that, and the plaintiff says with respect to that, 'why did you abandon it, if you found your porous chamber so useful, why did you pull it down and substitute a boarded chamber in its place?' and then he applies that observation, in point of law, to which I called your attention at the outset of the case, knowing that you would have to apply in the course of the case. That being an experiment, or an unsuccessful attempt, it is not an anticipation of the patent. The defendant says, I am to blow air through the porous fabrics—I am to conduct the air through the porous fabrics; I did it. The plaintiff says, so you did, but why did you leave it off; why did you (upon your own evidence) change it for a boarded fabric? Besides which, if the 3rd claim is (as my brother Willes thinks it is), connected with the 2nd claim, then the process described in the 2nd claim is a portion of the process described in the 3rd claim; and there is no doubt at all upon that reading of the patent, that the blast as described in the 2nd claim was not the means of filling that stive chamber.

Mr. Aston: Exhaust chamber, my lord.

"Mr. Justice Byles: I call it stive chamber. I do not know whether there is any evidence that they call it so—they may call it what they like. Calling it a stive chamber, will not make it a stive chamber.

"Gentlemen, that is the first observation which occurs upon what was done at Isleworth, but the plaintiff makes another. There are many more that have been made, and may be made, but if I were to repeat all you have heard at the bar, of course I must make the two speeches over again. Mr. Bovill, I think, at some subsequent period, received from Mr. Kidd the sum of £3,250, for leave to use his (Mr. Bovill's) patent. Now, if Mr. Kidd's were an anticipation, Mr. Kidd had been using Mr. Bovill's patent all the time, and why should he give £3,250, to be allowed to continue to use it? You have heard the explanation which has been given about that. It is not for me to enter into these details; you heard it commented upon, on both sides, and to those comments, as the only impartial comments that can be made, I leave you.

"Now, gentlemen, I am passing very rapidly through these things as I said I should. Do not suppose—

"Mr. Webster: Will your lordship excuse me. You said that there was no plenum in these cases. As I do not agree with that, I take leave to suggest it. I do say there was a plenum in the sense now put upon it, because there was this fulness of the sides.

"Mr. Justice Byles: What evidence is there as to that? I do not like to reason with counsel. What evidence is there that there was such a regulation as to draw up the plenum neither more nor less?

"Mr. Webster: I did not say anything about the regulation; I say, in point of fact, there was the plenum.

"Mr. Justice Byles: No doubt, gentlemen, it can be done, and that induces me to make an observation upon an answer, remembered by one gentleman of the jury, who has paid great attention to the case, and who, I am quite sure, carries an understanding to be convinced on the one side or on the other side, as the evidence at the last will appear to him to require. That evidence came out with respect to the Kingsford Mill, but I may as well mention it here because the counsel has said, there is an exhaustion of the plenum. There was a witness called then who said, the fan may be so regulated, that a great portion of the meal may be taken up, or it might be diminished, so that a feather might be suspended in the atmosphere. That comes to this. In their way of working in these cases, you may by means of your process, have such an atmosphere as that a feather will not stir; which is precisely the atmosphere that you must have. But was it so worked? Of course it can be, because if a man has a powerful exhaust, he can exhaust it to a very small degree, so as to produce less effect, or to a larger degree to go up to the plenum, and go beyond it, and to suck up the stive to the meal-spout. He may do all that, but the question here is, did they invent or even know of that precise point at which you are to stop—plenum and nothing more. That they could have done it, there is no doubt, and at every time when the exhaust was set to work, there must, I should think, have been some period or other when it was done, whether they knew it or not. But this is not a patent for a machine. This is a patent for a process; and as, if there be a patent for a medicine which is composed of several ingredients, and one of them is very hurtful in one dose, and very beneficial in another, the amount of the dose is the very essence of the invention. So here, the quantity of air that you suck up is the essence of the invention, and I do not see, I must confess, in this case of the mills at Isleworth any evidence at all that they confined themselves to the plenum and nothing more, although, no doubt, they had an instrument which would do it, but then this is not a patent for the machine. This is a patent for the process.

"Mr. Webster: There was evidence as to the regulation of the slides at Isleworth.

"Mr. Justice Byles: I cannot at all qualify anything that I have said, Mr. Webster; but perhaps I may say this. To say that there were the means of regulating it is one thing; to say that they did regulate it up to a certain degree—no more, no less, is quite a different thing, and as to that different thing I see no evidence at all. I will come now—I am going very rapidly through it, and I shall soon have finished—to Mr. Potto Brown's case. In Mr. Potto Brown's case I see no evidence as to the plenum being taken up, and nothing more; but there is this in Mr. Potto Brown's case, which seems to me to have a bearing upon the invention—the stive room. Mr. Bramwell tells you that there is no particular form for a stive room; that it may be made any way. But he says, the great thing in a stive room is to have plenty of that straining apparatus. I do not suppose that the four sides and the top are necessary in that particular form would prevent an anticipation from being fatal. Mr. Potto Brown it seems—I speak from memory now of the evidence—had an upper chamber, and across that upper chamber hung a curtain. That curtain was fixed, as I understand it, to the top, and to one side, and kept by weights down to the bottom. On the other side of that, where there was a curtain, there was another chamber, and in that chamber there was an aperture, which communicated with the open air. A witness was called for the plaintiff by anticipation—I forget who he was—who said he went up there some time since, and there was an old dirty curtain, and Mr. Potto Brown was examined, as to whether there were trunks. It seems to me the question in Mr. Potto Brown's case, is whether he anticipated the last claim? Whether he had a suitable porous fabric for filtering the flour from the air, in the manner herein described? Gentlemen, I have given you a very rapid view of it. I trust to your memory for anything more, but I am ready to read any part of the evidence that you require. But they say, of Mr. Potto Brown, you are come now as a witness against this patent; we have the means of showing that you yourself have admitted that your anticipations were no anticipations at all. And here I do not believe, that the learned counsel intended any reflection upon Mr. Potto Brown. Gentlemen, I have not the honour of a personal acquaintance with Mr. Potto Brown, but having been for many years a member of the circuit in which Huntingdon and Godmanchester are situated, I know him to be a man of the first respectability. I think I may without impropriety say that in his favour, and I rather discouraged the learned counsel for the plaintiff from pursuing a line of cross examination, which, when addressed to persons in the position of Mr. Potto Brown, Mr. Kingsford, and other gentlemen whose names at this moment I forget—Mr. Podger, I think, was one—I think are misapplied; but I have really no occasion to complain of the learned counsel. Now that is the substance of what he did. Let us see what he has said. Again I say, I do not mean to reflect upon him in the least, but if I can find his evidence, I might refer you to one or two passages in it. Lest I should do him injustice, and as I happen upon it, I will read you his account of the chamber now. 'There was a fan to draw the hot air, and the stive and damp into a chamber; from thence into an upper chamber which was divided by a curtain. On the outer side of the curtain was a long tube covered with a cowl, through which the air communicated with the outer atmosphere. We at all times called it the blower chamber. The curtain was of porous fabric. It was attached to the top. It touched the ceiling; it was nailed to the ceiling and firmly tacked down on the side of the chamber. It was weighted at the bottom to keep the air from blowing it away. The other side was attached to the chamber by loops, or strings, to allow us to get to the outer side of this curtain; the air got through the fabrics, and the stive did not get through the curtain, but was deposited in the inner chamber,' that is his account of what was done. Now he has been asked upon cross-examination to say as to what was said on a former occasion, not long ago, before the Privy Council, when the prolongation of Mr. Bovill's patent was deliberated upon, and I suppose counsel were heard and witnesses examined. It is no contradiction of what he says to-day, because he is not allowed to-day to give his opinion—it is for the jury. He tells you what is done, but you had an opportunity of hearing what he himself said upon it. He said before the Privy Council in 1863—which is now four or five years ago—'I was of opinion that my machine was different from Mr. Bovill's and the result different. I said, my machine does not produce a vacuum; it is constructed so that it should not produce a vacuum. It does not produce a vacuum like Mr. Bovill's. As to the blast, I do not touch Mr. Bovill's patent, and as to the exhaust, there may be a question.' You know, gentlemen, the exhaust is the very thing which supplies this chamber. 'I say mine is totally different from Bovill's;' and again he adds, 'I say mine is totally different from Bovill's—my exhaust may be like it, but that would mislead; but if I explain further, I could show that the exhaust is quite different from Mr. Bovill's, but I will not give an explanation. My exhaust is made on the principle never to produce a vacuum. There is a difference in that part of the construction.' Whether he is right or wrong, I do not pretend to say, but there certainly seems to have been a time when he was strongly of opinion, that there was the greatest possible difference between any part of his process, and any part of Mr. Bovill's. Then the same thing happens to him as happened to another witness. In 1867, he takes out a license. That license is put into writing, and it is laid before you. What is the consideration for that license—can any gentleman tell me?"

"Mr. Garth: One penny per quarter, they were to pay in the other two mills for the future.

"Mr. Justice Byles: You are right."

"Mr. Garth: And also for the past."

"Mr. Justice Byles: One gentleman pays two pence a quarter, and one, one penny a quarter. The gentleman for the future, I believe, is to pay one penny per quarter. Now this license contains this recital—'Whereas the same patentee under the order made in the same cause, inspected the mills respectively on the 25th of July, 1867; and whereas after such inspection, the said patentee and licensees on the said 25th of July mutually agreed, and admitted that the exhaust apparatus used by Mr. Brown in the Houghton mills is not an exhaust of the plenum of dusty air from the mill stone cases as described in the specification of the Letters Patent'—that is an agreement by him to the effect that this is not an anticipation, and that he pays a large sum for getting this license—but that the exhaust apparatus erected and at work at the said Fenstanton and Godmanchester mills respectively, does draw off all the warm dusty air from the mill stone case, which would otherwise be blown down the meal spout, and by which the dust in the mill is avoided as described in the specification—that machinery being put up I believe in 1855 or thereabouts, and therefore being no anticpation of this patent. Now some strong observations have been made to you, not upon this gentleman's credit, for there can be no doubt that he is speaking the literal truth in what he says; but they say:—Trust his judgment when he was before the Privy Council, and trust his judgment as to what he says, when he pays a sum of money, and puts it down under his hand. I am afraid I heard some observations from the bar, but not from either of the counsel who have addressed you, which seemed to me rather hard, as to the nature of this deed. It is quite clear this deed would not be prepared without the presence of a solicitor on both sides, (for it is very carefully drawn up), who would advise their respective clients as to what was the fair and proper agreement between them.

"Now, gentlemen, I shall pass with the same rapidity to the examination of the next case, which is Muir's case. Here, as in the former case, there is no regulation of the exhaust so as to take away the plenum and that only, nothing of the kind in Muir's case. If there is any anticipation at all, it is I suppose in the stive room. That I may not make a mistake, I think I must trouble you very shortly with some part of Muir's evidence. An exhaust alone I have told you is no infringement. That this exhaust was not confined to the suction of the plenum, not only does not appear, but the contrary appears, because it appears I think in his case that it was necessary to use a washer to clean the tubes, through which what was drawn up by the exhaust did pass. It is sufficient to say that there is no evidence to show that it was so regulated; but he had a stive room, as he calls it, divided into three compartments. They were parted by a partition, with holes half an inch diameter. The second compartment was divided from the last, by a curtain or screen of biscuit sacking. It was nailed on the top and roped, and secured to the floor by wooden battens. From the top compartment there was a ventilator, which went out to the top of the roof, the cowl and ventilator giving free access to the outer air. The result was that the hot air was distributed over the surface of the first room, and from the first room it went through the holes, as I suppose about an inch in diameter, into the second room, and from the second room it was strained into the third room through porous fabrics, and from the third room it went by a funnel or cowl into the open air. I can see here no evidence of any infringement of the second claim. If there is any evidence at all, I should say it must refer to the stive chamber. It is the stive chamber as compared with Muir's; one the boarded chamber, with holes through the second chamber, the second being all boarded except the curtain dividing it from the third chamber; and the last third chamber communicating by a cowl with the open air. In your judgment, is that such a stive chamber as is there represented? Besides which, if the stive chamber of Mr. Bovill is a stive chamber connected with the exhaust, which serves it, by being connected with the second claim, according to the judgment of my brother Willes, that introduces a further difficulty in the case.

"The next case is Wren's and there the only thing happened which I regret in this case. I was very anxious that the witnesses should not be out of court in this case. It is very unusual in a patent case to order the witnesses out of court. It makes this difference—if one witness has not heard what the other has said, you cannot ask that witness in a compendious way, as is commonly done, Do you agree with what so and so has stated? It lengthens the case prodigiously. However, the counsel for Mr. Bovill thought fit to insist upon it, and has endeavoured to say that which he has done is quite right. I do not say that it was wrong, but it has lengthened this inquiry considerably.

"But now in this case he would have had just the same advantage if the witnesses had been in court, for his case depends in a great measure, though not entirely, upon the evidence of a man of the name of Wren—John Hansell Wren. There was no stive chamber, if I recollect right, in this case.

"Mr. Webster: Yes, my Lord, in Wren's case there was.

"Mr. Justice Byles: Yes—two chambers: you are right. 'The fan cleared off all the stive; the meal was cool. There were two chambers—they were let in in 1847 or early in 1848: we connected the pipe from the mill-stone case with an exhaust fan and pipes. We moved the stive room. There were two rooms on the attic—that was before it was connected with the dressing machine—the other was the meal room; that is the room below the attic. The dust from the mill and the dressing machine was discharged first into an attic chamber, then into the meal room. The fan cleared off all the stive; the dust went into these two chambers; they were let in in 1647, or early in 1848.' Then he speaks of the blast and of curtains: now the same observation, with respect to what is called the stive room, occurs here, that I have made in the other cases. You will judge how they are justified, but I am sorry to say there is another observation that is to be made here. Time here is of the essence of what done. If what was done was done in 1847 or 1848, then the question of whether this be an anticipation arises, but if it was not done until 1853, then it was no anticipation. The witness has been shown an affidavit of his own, and he says that affidavit states what is not true. It is his own affidavit, in which it is alleged that it was not in use in the year 1853. It is suggested, and may properly be suggested, that when an affidavit is drawn by the solicitor in the case, that very often affidavits are sworn, as they ought never to be, without due deliberation. I may say sometimes a gentleman has to swear an Answer in Chancery as thick as an octavo volume—what does he do? He is liable to be indicted for perjury if he swears falsely. He relies on his attorney, in whose hands lives and reputations are, even in the case of persons who have been brought up to a knowledge of the law; and very safely trusted they are, I must say, as a general rule. Still here is a man who has gone through that affidavit, and made alterations in it, with his initials in his own hand. I must say, without saying that man is to be believed or not, that you probably would not allow his evidence to turn the case with respect to this alleged user. There is, however, his brother, Benjamin Wren, who corroborates the subsequent statement of the other brother, that this took place before the patent, and there is a good deal more, with which I do not think it is necessary to trouble you. Gentlemen, I now come to Kingsford's case. Mr. Kingsford's case may perhaps best be proved by the evidence of one of the workmen.

"Mr. Garth: There is also Fison's case, my Lord.

Mr. Justice Byles: I have not forgotten that, that is the Ipswich mill? —Mr. Garth: Yes.

"Mr. Webster: The witnesses as to Kingsford's mill were Horn, Crisp, and Kingsford.

"Mr. Justice Byles: Gentlemen, the first witness called is Mr. Horn, whose evidence is this: 'In 1848 I saw the exhaust in full operation in Kingsford's mill, with six pairs of stones, six trunks leading to one main trunk—they were carried across the mill by a pipe—there was a pipe connected by an exhaust fan, and that drew up heated air with stive. The meal descended in a cool stream below. The heated air or stive was exhausted into a square wooden room. On the bin floor, a portion of the bin, a hole was cut through the ceiling of the bin floor, into the stage floor, on which, and directly over, was the second stive room, one side being the mill, and the other three sides of bagging work. Directly through the roof was a stive funnel, through which the heated air finally escaped into the atmosphere, and under that was a tub, which was to contain the water which was condensed, and the stive was taken away entirely from the millstone cases.' Now that was spoken of by Mr. Horn, by Crisp, and Mr. Kingsford.

"Gentlemen, the same observation applies with respect to this which applies to all the rest. What were these rooms? Be they bagging rooms, or be they chambers, without any opening. Was that at all like that thing which you have before you in substance? That is the question. It is important here to observe, the one great object seems to have been, as in one of the French patents, to promote condensation, so as to remove the moisture, but I shall only be repeating what I have said before if I go farther into that. You will say whether this in your judgment performs the process which you have before you, and whether they do or not, whether they were anything more than experiments without succesful user.

"Then a gentleman of the name of Fison is called, and I do not repeat in this case what I before said about the evidence as to the feather in the mill stone cases. I have already observed upon that, although it relates to Kingsford's mill. Besides that there is the case of Mr. Fison at Ipswich to which I must call your attention. Mr. Fison says, he was a miller at Ipswich in 1845, and owned the mill at the beginning of 1848, and there were three pair of stones. He said he put up an exhaust fan and connected it with all three pair of stones. The fan was on two floors, a spout from the millstone case with the fan, and it blew out the hot air and stive. Meal went down the spout. The best part was immediately round the fan on the floor, that is, the best part of the flour as I understand him, 'the remainder separated a little further like snow on the bank;' there is nothing here about the pleuum. The question is again about a stive room, according to that the air would be driven through and the stive left behind. Here there does not appear to be any porous fabric as far as I understand it—'the remainder separated a little further like snow on a bank. It answered perfectly well, it kept the mill free from dust, and improved the condition of the meal for the fine drossing of the flour. That is the substance of what he states, and you will say whether that is an anticipation.

"Now I have called your attention therefore to the three Huntingdon mills at Godmanchester and St. Ives, to Mr. Muir's mill, to the Stockton mills, to the Ipswich mills, to Kingsford's mill. The New Crane mill has been abandoned. That, I think, exhausts the list of anticipated users. Now I beg to say again, as I began, that most of the observations I have made upon these mills, except so far as the absence of the exhaust is concerned in the 2nd claim, are questions of fact for you, not questions of law for me. It is for you to say whether the plaintiff's patent was anticipated by these users made of his invention by people who had invented it themselves in substance so far as their user goes, or were they merely tentative users if I may so speak, experiments—unsuccessful users. You will judge of it, you will also judge how near they come to his invention, and you will also judge of the time. An observation fell from one of you, gentlemen, which is applicable to many portions of this case—it will be safer not to act upon doubtful evidence.

"Now unless you desire me to do more, I shall content myself with that statement of the evidence on both sides. I have gone through the defendant's evidence at greater length than I have the plaintiff's because of course it is more in detail. There is, however, one observation which I think I ought to make with respect to the Isleworth mills, and I do it in two or three words. The plaintiff says that there is a mistake as to the date of the alterations at the Isleworth mills, and that Mather is wrong as to the dates. He calls two or three witnesses who say that those alterations, whatever they were, were not made until after Mr. Bovill's patent. I could not help saying, when those witnesses were in the box, that is a very easy thing to prove, because if you went from Uxbridge then surely there must be some entry in some book, or some bills of parcels, or something or other to corroborate you, but upon further reflection I doubt whether that amounts to anything, because the same observation might be made on the defendant's witnesses when they made the alterations, for although the alteration was then made by the defendant's men, yet of course he would have had a great many materials, there would have been I should have thought both in the one case and in the other, by persons accustomed to get evidence, which *nisi prius* lawyers understand, plenty of means of showing the date. Therefore that observation should either go for nothing or you should apply it to both.

"Gentlemen, I come now, lastly, to the alleged anticipation by written documents. I shall go just as shortly through them. I am willing, as far as my ability goes, to explain them further if you desire it. First, the Scotch patent. That has no application that I am aware of to the stive chamber; it only applies to the exhaust—to currents of air produced by blast or exhaust. Those are the words of the patent. The patent in effect as I understand it comes to this, you drive the air through or suck it through as you like, but without any limit and without any regulation; there is nothing there to anticipate the stive chamber, and if I am right in point of law with respect of the exhaust of the plenum there is nothing there to anticipate the plenum. The English patent of 1846 creates currents of air running through the grinding surfaces. There is nothing there affecting the stive chamber. There is nothing there affecting the question of the plenum. You are to take care to take enough, and it is not said how much you are to have, besides which the evidence is that as to that, although the defendant's witnesses some of them say that it answered very well, the plaintiff in depreciation of his own patent says it filled the mills with dust.

"Then the learned counsel for the plaintiff has made this observation. He said, if that patent was so good a patent, why did not the plaintiff keep it? Why should he run the risk of taking out a fresh patent? Above all, why did he take out his patent in 1849, which he, as a man of science must have known, if this version of the effect of the English and Scotch patent be good, would be avoided by either of those patents? Certainly he would not.

"Now, gentlemen, I come to the French patents, and I shall be very short upon them. My brother Willes, in summing up, I see, said scarcely anything or very little about them, but I shall say a little more. With respect to Damy's patent that was in the year 1841. The main object of that patent, as far as I can understand it, and I understand it but imperfectly—you have heard counsel upon it—is to condense and to deprive of humidity by forcing the air through the stones. Condensation is the object of the invention. You have heard it read and commented upon, and you will say with respect to that whether it did anticipate the plaintiff's patent; and, further than that, whether in your judgment the description of it is such as that a competent person could make it? There is this observation made upon it, and which is made upon all the other patents. There is no reason to suppose that they were not worked in France. Whether there is any previous evidence that they were I do not know, but no person has ever seen them at work in this country. No doubt there were accounts published of them in the British Museum, which would be sufficient to avoid this patent if they were good patents, and have the effect which the learned counsel for the defendant alleges that they have. I may say, with respect to that, in addition, that there is no reference in it to a plenum, no mention of the regulation of the draught. With respect to Vallod's patent, which was in 1839, there is no reference to any fulness of the air, or to any regulations to remove it. With respect to Cartier's or Debeaume's patent, which are both in, there is a partial vacuum produced, and there is an exhaust into a receiver. I leave those French patents for your consideration. I dare say you will say they afford you very little light because you did not fully understand them, and I say that with great humility, but with great sincerity, for myself. There they are before you.

"Gentlemen, I believe that I have gone very shortly through the whole of the evidence in this voluminous case. Now, if you please, before you retire, we will go once more through the questions for you. I have had them written out for you from the record.

"Now let us see what the questions are. The first is a patent for a combination—was this new, 'fixing the top stone.' They say that was a novel thing—not that the top stone was never fixed before. I do not know whether it was or was not, but in this combination it never was. 'Fixing the top stone and causing currents of air, either by exhaustion or pressure, to pass between the grinding surfaces of mill stones when the top stone is so fixed, and in the introduction of the ventilating pipes in the stones as herein described.' Was that a new combination? If it was, verdict for the plaintiff upon that. If it was not, verdict for the defendant. Again, I repeat, the question is not whether some things are old and some new, but was it a new combination? The utility is not denied.

Secondly, I will read the part to which reference is made by the words 'herein described' first, and read them together: 'This part of my invention relates only to sucking away the plenum of dusty air, forced through the stones, and not to employing a sufficient exhausting power to induce a current of air between the mill stones without a blast, this having before been practised as above mentioned.' Again, 'this part of my invention relates only to sucking away the plenum of dusty air forced through the stones.' Now read the second claim: 'Secondly, in exhausting the dusty air when the same has been blown through the grinding surfaces of the mill stones from the stone cases or chambers receiving the meal as herein described.' The plenum, I again repeat, is the essence of it, and the plenum is what I have described to you. If I am wrong in that, the whole of these proceedings may be set aside, and the parties may if they please take the judgment of the House of Lords upon it.

'Lastly, I claim the passing of the dust and stive caused in the process of grinding through suitable porous fabrics, by which the flour is filtered from the air as herein described.' 'As herein described' means this—The third part of my invention consists in straining the stive or air by means of a fan or other exhausting machinery and blowing 'the stive so exhausted into a chamber having its sides and top formed of one or more thicknesses of suitable porous fabrics to allow the air under pressure to pass out deprived of the flour by means of this filtration.'

"Now, gentlemen, this patent is before you in the nineteenth year of its existence, and it is for you to say upon these facts whether it is a good or a bad patent. You may sit many years in a court of public justice without having so much property to dispose of as you will dispose of here by your verdict. Of one thing I am quite sure—you have endeavoured to understand it, and of one thing I am surer still, that you will give a perfectly honest judgment. Now, I will hand you the specification of 1849, a copy of the questions, and lest there should be any possible danger of those questions having been mis-copied, I will hand you the record also. You will recollect that those two things are the same—one is on parchment and the other is a copy of it on paper; and there you have the questions sent by the Master of the Rolls. Here are the questions separately, there is the record, and there is the specification."

A Juror: My lord, if we should not be likely to agree, should we then have to assemble to-morrow?—Mr. Justice Byles: I shall be here to receive you to-morrow morning, but you will sit in your own room all night.

The Juror: We are not to depart but to return the verdict if possible.

Mr. Justice Byles: You do not separate until you have returned your verdict. If it should not be to-night, I will be here at 10 o'clock to-morrow morning.

The jury retired at twenty-five minutes past four, and returned into court at nineteen minutes before six.

The jury answered to their names as they were called by the associate.

The Associate: Gentlemen, have you agreed?—The Foreman: We have.

The Associate: How do you find?—The Foreman: For the plaintiff.

Mr. Justice Byles: A general verdict for the plaintiff, gentlemen?—The Foreman: Yes, my lord.

Mr. Justice Byles: On all the issues?—The Foreman: Yes, my lord, on all the issues.

We shall have occasion further on to mention the attempt made by Mr. Goodier to obtain a new trial and its results. For the present we content ourselves by reminding our readers, that what the learned judge relied upon as conclusive to show that Mr. Muir had not done the same thing, as Mr. Bovill's invention was—namely, since it was necessary for him to use a piston to clear out the exhaust tube—the very proof relied upon by Mr. Bovill, that Mr. Goodier had been using the invented regulated exhaust of the plenum; that his lordship expressed his implicit belief in Mr. Muir's evidence, but held that what he stated he had done, was not an anticipation of the patent, whilst the Vice-Chancellor, Sir W. Page Wood had expressed himself as strongly to the effect that the evidence of Mr. Muir, (whom he had not seen and who had not been contradicted), was not deserving of belief, but that if it had been creditable, there is no doubt what he had stated he had done, was an anticipation of the patented invention. And the same eminent judge agreed with Mr. Justice Byles, as to the veracity and accuracy of Mr. Potto Brown, but held that he had not anticipated the invention, because, although he had exhausted the plenum precisely, he had done so by a different contrivance, whilst Mr. Justice Byles held that, though he had used the contrivance, and might by it have exhausted the plenum that was no proof of anticipation, since the invention was of the process and not of the contrivance or apparatus.

We shall also see that Lord Cairns decided that Mr. Potto Brown's evidence, though uncontradicted, was unfit to be acted upon by a court of justice, because Mr. Bovill had given him a release from all claims and had assented to what Mr. Brown had all along insisted upon—namely, that the use of exhaust without blast was a different thing from that protected by Mr. Bovill's patent.

But first we must show how flexible language may be in the hands of a judge, and shall present to our readers the judgment of Lord Cairns in Bovill *v.* Cowan.

(To be continued.)

The three races between the English yacht *Cambria* and the American yacht *Sappho* have resulted in the defeat of the former in the first and third of the matches, and a refusal of the second. We wonder whether the so-called "improvements," effected by filling up the hollow lines of the *Cambria*, had anything to do with her signal overthrow.

The submarine telegraph mania appears to have collapsed, the shares of several of the companies being at a discount of more than 100 per cent. of the amount paid; consequently they can be bought for somewhat less than nothing.

INSTITUTION OF NAVAL ARCHITECTS.

THE CHANNEL PASSAGE.—VESSELS AND PIERS.

By Vice-Admiral Sir Edward Belcher, K.C.B.

The subject to which I am about to direct your attention is, principally, the proposal to connect England and France by continuous railway communication, the gap, that is the Channel interval, being bridged by steamers fitted to receive and convey the trains across, and deliver them on to the rails on the French shore. And it is inferred, from their great size and beam—fitted also with heavy sponsons and paddles—that they will not roll deeply, and consequently tend to prevent that misery to weak stomachs—sea-sickness.

Now, as regards the rolling motion, I am not satisfied by assertion, when diametrically opposed to personal experience, seeing that the worst rolling affecting vessels engaged on Channel service, caused by waves set in motion by the whole western space of the Atlantic Ocean, causing, as seamen term it, merely "the deep but easy roll," is not reckoned as due to a gale, for with sufficient wind a vessel is steadied by canvas. The serious rolling is due to an opposite cause, the absence of the gale, when that unaccountable ground swell which tumbles into the Bay of Biscay lifts also at the limit of soundings in the English Channel, and rolls in successive waves home to the shores of France and England, even up to the Goodwin Sands.

To adduce an example of the inefficiency of beam to prevent heavy rolling, as in 60ft. vessels ranging about 2,000 tons, in a perfectly glassy calm, I may mention the following:—The Brest squadron anchored in 1812 in Cawsand Bay, before the breakwater was commenced. It consisted of various types. Thus the *Ville de Paris* and *Abercrombie*, French, *San Joseph*, Spanish; *Norge*, Danish; *Queen, Conquestador*, and *Magnificent*, English; lower yards and topmasts struck, riding at single anchor. It had blown heavily from S.S.W., and terrific long-jawed rollers set in. These vessels rolled fearfully, and it was asserted that the *Queen* and *Magnificent* rolled "keel out."

I then belonged to the *Abercrombie*, and being an invalid, in the captain's cabin, was lashed in two chairs at one of the ports, commanding a complete view of several ships, and especially of the *Magnificent*. The foam certainly warranted the conclusion, as nothing but the "keel awash" could have produced it.

This point, however, is immaterial. It will be said the vessels of that period were short, and deep rolling naturally; yet it was rather increased, as in the case of H.M.S. *Rodney*, when Sir W. Symonds, at a much later period, increased the beam, tonnage, and draught; and in 1823, we have proof of what heavy gales and rolling seas effected on the breakwater at Plymouth Sound.

I have had some experience in crossing dangerous bars attended by heavy following rollers; still the roll at good speed on the ship was far from agreeable—indeed, I must admit dangerous. My object is merely to show how heavy, deep, and quick rolling is a Channel difficulty, and not to be lightly despised; and that, in considering the fitness of vessels for this peculiar service, we must not fancy that a stroke of the pen or a paragraph in print rules the waves. It is our business, as pretty well tried seamen, to state what is our opinion on such matters belonging to our "craft"—what is the proper character of vessel fit for such service as contemplated; and, more, whether this railway system, carried afloat, is either practicable or judicious, specially, too, as regards reasonable expense; what should be the form, size, and speed for the contemplated service; and finally, the probability of success by any of the types offered; or if a variation, dispensing with the train system, using the present or improved harbours, or improved ships, might not equally meet the present difficulties.

I must at once observe that my own opinion, as far as safety, comfort, and freedom from that jarring, creaking, and straining, which tophamper, projections, numerous joints, gimcrack ornaments, and fastenings is concerned, the beautiful drawings which have come before me bring to my mind no idea of peaceful repose, but rather that idea of Pandemonium which the agonies of one of our old line-of-battle ships forcibly brought to my recollection. Now, what do we require for an hour's travel across the Channel? A vessel to carry us safely, and not offering us enjoyments not to be enjoyed—a structure which shall be the type of strength, smooth as the back of a whale, offering the least possible obstruction to wind or wave, and carrying a light pilot tower on the summit—in fact, a type of our ugliest ironclad, the beauty *par excellence* of our present navy.

Our outline decided, the interior fittings, those of the simplest nature succeed. To passengers who fancy the whale's back, I would offer just such enlarged accommodation as the *Cigar* ship had (85ft. long by 8ft. wide), by a light hurricane house and rail enclosing the turret pilot tower, the type indeed of a felting around the funnel of H.M.S. *Carron*, for surveying duties in bad weather.

The velocity proposed by the advocates for these rail boats is 20 knots; that involves, under paddle or screw, no small amount of vibration, but sea sickness is not the result of violent motion. It is, so to speak, barometrical, the action of the diaphragm (like the aneroid) rising and falling with the motion of the ship, and specially acting on the nerves when it is influenced by the sight.

For my own part, I plead guilty to being subject to sea-sickness, but varying with the size and quickness of motion, greatest in the ships of the line, less in a cutter. If carriages are to embarked for the hour's passage, no individuals but those possessing sea-legs would care to quit their *pose* to enjoy the deck, or smoke their pipes under the lee of the pilot tower. All fittings but those absolutely demanded obstruct the free circulation of air, inducing faintness and sea-sickness, and consequently should be avoided.

It should be borne in mind that when we propose to construct great ships to carry such great burdens as railways and their passenger and goods trains, we pass out of the range of depths afforded by the harbours now in use; and therefore if you construct vessels capable of carrying them, you are bound to meet the question of inability to enter at certain times of tide and under certain conditions of weather. It therefore follows that your vessel must not only be calculated to cross the Channel, but also, if necessity demands, be competent to take care of herself at sea, or to return your passengers, free from sea-sickness also, at a safe port. Now, looking to certain plans and models to which my attention has been drawn, I must remark that such absurdly decorated craft, with all the paraphernalia copied from the boats engaged on the inland seas of the United States, are not fit types for our Channel service.

If the floating railway schemes are to prevail, I see no difficulty in meeting the demand for proper vessels, provided, as in our harbour defences, money is to be cast away freely in the construction of adequate harbours, and if those structures are adopted, I am prepared to meet ships as well as harbours of refuge, but I cannot shut my eyes to the risks and delay of stone piers. The disruption of the breakwater at Plymouth, January, 1823 (of which I hold in my hand a copy by Whidberg, addressed to Sir Isaac Coffin)—solid cemented masonry of some ten years' settlement—and at a later date the works at Alderney, erroneously assigned to my proposals in 1842 (but absolutely void of truth, seeing that the scheme proposed by me was to be carried out at Ret harbour, on the opposite side of the island by inland excavation similar to that since carried out at Cherbourg), all attest the difficulties to be surmounted—foundations in deep water and the surf to prevent or delay completion. But before we proceed, as to the vessels fit to carry out this railway conjunction, and, moreover, to be impelled at a standard velocity to agree with railway time, of twenty knots or more, have satisfactory computations been made, not as to chamber practice on paper, but as to all dangers and difficulties of that wild sea, not in a smooth dock, but, as sea-sickness is imported into the question, to the absolute security of life and property, on so small a draught as 5½ft.? The plan of Mr. Fowler, giving 13ft., is nearer to reason. That would agree with my own dimensions of 400ft. long by 60 beam, but nothing then to spare.

Before these rail-connecting vessels are built, it is incumbent to construct piers or harbours to receive them. And if those structures are to be carried out, we should execute them on the most economical yet certain plans, bearing in mind the probability of the very close supercession of their services by the tube tunnel or bridge of the future. At this present moment I see too many difficulties to be mastered before success can be deemed, in either of the great plans, even to loom in the future. But having such perfect confidence in the rising talent of our engineers, I feel certain that eventually a more satisfactory mode will be triumphant, for that ugly term "impossibility" but whets the ardour of inventive faculty.

First, then, if the railway question prevails, we are prepared to provide a safe vessel fit to proceed, not merely across the Channel, but even beyond the narrow seas, should she be caught in one of our severe gales on a lee shore. On the other hand, if we are satisfied with the present harbours, with their present depth of water within, and determine to improve them at moderate outlay, then we are prepared with a vessel similar in all respect for the customary traffic at the less draught of 7ft.

For extension of piers and adaptation of the same for the large boats we are also prepared.

And here I must observe that I underrate none of the schemes before the public, as simple computations; but, as a seaman, I am satisfied that grief would come to any one of those proposed vessels unfitted and incompetent to perform full sea-work if driven into the Atlantic.

Starting, then, on the principle that it behoves us, first, to utilise and improve what we have before we cast our riches on a foreign shore, to be depreciated at no distant period by other yet more expensive undertakings, I fall back on the class of vessels which I have to propose; and I may add that, under any change of circumstances, the outlines, in relation to size and depth, will preserve their features, the form being that of an ovoidal box, smooth from end to end, the terminal points being open to receive railway carriages of 8ft. in width.

The following dimensions show the three classes:—

No. 1	13ft. draught.
No. 2	10ft. „
No. 3	7ft. „

Channel Service Steamers.—Mail Railway Service.

13ft. Draught.		10ft.	7ft.
Length	400ft.	350ft.	300ft.
Draught	13ft.	10ft.	7ft.
Beam	60ft.	50ft.	45ft.
Displacement	4,000 tons	3,000 tons	1,600 tons
Indicated H.P.	8,000 tons	5,000 tons	3,500 tons
Speed	18 to 20 knots	20 knots	25 knots
Keel to deck	23ft.	With one line of rails to carry luggage - goods' waggons, but not passenger trains.	No rails
Deck to promenade ditto	13ft.		
Saloon, height	8ft.		
Steering house above ditto	7½ft.		
Deck of saloon	200ft. by 30ft.		
Promenade ditto	300ft. by 60ft.		
Could carry on rails	300 tons		

There is one feature in this arrangement which, whether the vessel carries sails or not, offers important comfort to ladies and invalids, and preserves intact the comfort of the carriage in which they embark Thus the side cabins are in such connection with the doors of the carriages that they can be used for exercise or accommodation during this all-important hour of travel.

The rails occupy the centre line; the carriages are home to the side cabins, and are run in and out by switches leading into the main line.

Both ends are fitted with closing shutters like shopfronts, and, being closed at pleasure, ensure in fine weather thorough ventilation, and in bad keep out wind and sea.

The mode of propulsion to be given is that of the hydraulic propeller or turbine. It possesses the advantage of smooth sides and perfect protection from injury from external force, and is therefore better adapted to take the sides of any irregular dock or piles.

I have special objection to the paddle system; it has not the power of sudden turning in the trough of a sea.

Further, the divided shaft proposed incurs enormous danger, and subjects the machinery to disruption, and vessels and passengers to enormous concussions.

Thus, on a even keel, it is submitted that a vessel of 400ft. rests on a series of waves. If, then, the trough between two waves denudes the lower float, the wheel will fly round and endanger the machinery.

As to the over-immersed paddle, it loses considerable propelling power, at the same time as that of its opposite is utterly lost, thus leaving less than half the propelling force on the ship, and causing consequent loss of speed. This I have witnessed, and more—the power of steerage under these circumstances nearly annihilated.

On this specific point the hydraulic rejoices in her superiority to all other modes of propulsion, seeing that the orifice in the air performs equally or better than that immersed, and the whole force of the engines being exerted to one purpose, and uninfluenced by wind, weather, rolling, or any external causes, acts with uniform force and precision. In fact, like the perfect chronometer, it performs equably and perfectly, secure within its case, just what is demanded.

The paddle steamer in a gale is always unpleasant to handle; the moment speed ceases she wallows in a sea-way, and the shocks of the paddle-boxes alternately striking are distressing even to those accustomed to sea life.

On the other hand, the hydraulic is but a simple vessel lying to or under small speed, and, but for the thrilling action when at full speed, few could imagine her propelled through the water. She is peculiarly adapted for the difficult work of turning easily in a sea-way, when, indeed, it would prove dangerous to the paddle.

Leaving the question of train boats and coming to the mere passenger boat (with carriages adapted for special objects, and, indeed, appertaining to the vessels), it is proposed to adapt them to rails, and to embark the passengers in them by the aid of machinery.

The difficulty—indeed, danger—which has always struck me, has been the embarking and disembarking—passing down slippery steps, frequently in dark nights, and having a lively dancing vessel ready to capsize you the instant you feel you have lost your land and have not gained sea-legs. This difficulty it is proposed to overcome by hydraulic lifts and cranes—lifting the carriages and passengers, with all their comforts about them, over openings in the upper deck, and landing them on platforms fitted to receive them on elastic springs, then moved to positions in direct connection with state rooms, door of carriage to door of state room, as before alluded to. The disembarkation would be similarly carried out, and carriages and passengers taken to the railway station or hotel, accompanied by all simple movables—heavy luggage being confined to proper trucks.

Now, in this mere passenger vessel of the third class in our table, drawing but 7ft., it is proposed, indeed, to attain the velocity demanded of 20 knots; but I much question, in attaining such speed, if you do not annihilate all idea of comfort or freedom from sickness. All will depend on the state of the weather. It is perfectly futile to expect comfort to those embarked if the force engaged in the propulsion is sufficient to shake the vessel to pieces, or so damage the machinery as to endanger vessel and passengers.

Leaving, then, the vessels, and looking towards their safety and accommodation on either shore, we arrive at the important question of piers. In November, 1836, I drew up for the Corporation of Preston a plan for the embankment of the Ribble, by a dam carried across from the Douglas River to the Naze, a distance of three-quarters of a mile. Mr. Stephenson, the celebrated engineer, engaged on the Clyde navigation, met me by appointment at Preston. That plan, which he most warmly approved, involved the construction by prepared iron caissons, to be simultaneously placed and filled, between the interval of two consecutive tides, with concrete, for which design I hold the thanks of the mayor and corporation, all other engineering authorities being set aside.

I will not contest the point with those who follow my ideas at the present day; but further, in 1858, I again proposed to saddle and fortify the Goodwin Sands by a plan of a similar nature. After an evening meeting at the Institution of Civil Engineers, my friend the late Charles May, and several leading members, adjourned to the rooms of Mr. Brunel, and discussed my plans. This resulted in the verdict pronounced by Brunel, short and pithy:—There can be no doubt of the correctness of your views; get money, and it will be done; compute the contents at 20s. per cubic yard, working expenses the same; government to supply the funds; it can be effected." So with the moot question of these piers for the accommodation of these steamers. Construct them in iron securely braced, ground and fill them in, previously working in screw piles to receive them exactly, and no sea can displace them.

It is not, perhaps, generally known that where iron forms part of the concrete and remains in contact with salt water for years, the iron becomes converted into a carburet, suffers no further decay, and becomes an incorporated crust-like glaze, similar to the surface of the old Dunes. All iron exposed for years on coral islands becomes attached to the coral block.

Finally, the important point to be considered is time and cost. It has been assumed that the work of forming harbours in masonry would demand at least three years. But I would inquire, looking to the number of days affording the term moderate, how many working days would be required? Then, as to the security from the work being demolished by any violent gale, and further the well-known fact that blocks under ten tons in weight cannot withstand much less wave impact than the exposed parts of our Channel shores—by the process I propose some thousand tons of matter would be securely placed within twenty-four hours—that is, at the first operation of placing, the weight of iron composing the caissons and the admitted water would be immovable, like a ship aground, by any sea. Therefore we may safely assume one-third gain in time, allowing a year for construction.

As regards expense, we may safely assume the same proportion—indeed less, if we take into consideration the risk of annual destruction by gales, an effect which never could enter into the calculation of cost by the method I propose.

INTERNATIONAL COMMUNICATION BY RAILWAY STEAM SHIPS.

BY John Scott Russell, F.R.S.

My communication is merely a very short supplement to the paper which I had the pleasure of reading at the last meeting. At the last meeting I communicated to you that, about four or five years ago, I think in 1866, Mr. Fowler was the engineer for the harbour, and I was the naval architect for the ships of a company who proposed then to establish this communication by railway-train steam ships across the Channel. The circumstances of this company, and of railway affairs indeed in general at that time, led to the abandonment of the enterprise, that is to say, to its postponement, notwithstanding that the Parliamentary notices had been given and all the necessary proceedings taken. In the meanwhile, I communicated also in that paper, the fact that I had had the fortunate opportunity of making an experiment likely to give us some information as to some of the practical points of difficulty in this system. I communicated to you then that I had just completed a steam-ship, whose dimensions were half of those which we proposed for the steam traffic between Calais and Dover. I was able to inform you then that that vessel had just started, and that it had done its duty. Now, that was all that I told you at the last meeting, and I thought that an experiment of a ship half the size, carrying half the quantity of train for twelve miles instead of twenty-four, a very good preliminary experiment. I am happy to inform you that my latest news from that ship is this—that from that day to this she has continued to traverse the distance with perfect regularity, and not the slightest accident has happened either to the ship or to the trains conveyed by her. I have also just received a photograph of the ship with the train on board, and I thought it might be interesting to you, while discussing the larger ship, to have before you the smaller one. I must say that I constructed this ship so as to be in every way a model for the larger ship, with one exception, that I could not get up model seas and model hurricanes for the occasion, and I had to take such seas and such hurricanes as the particular latitude in which the ship was plying afforded me. I am sorry to say that the waves of my little sea, which is only 100 miles long, and from 12 to 20 miles broad, are not at all such respectable seas as I have occasionally encountered between Calais and Dover, when I have made a passage of six hours between those ports. However, this ship proves the ease, practicability, and comfort with which the continual, regular, and daily shipment of trains may be carried on, and it proves the convenient enjoyment of a ship which is enormous for the small port she has to go into; and it proves, moreover, the extreme value of detached paddle wheels, with detached engines on the two sides, for performing those continuous and easy manœuvres that were thought to be impossible. That is all the conclusion I draw from this subject, and I say it proves the mechanical arrangement to be practicable, comfortable, and convenient. It does not prove at all the cause of the measure of oscillation of the ship proposed for the Channel in the actual great rolling waves of the Channel.

Gentlemen, I will now add to the information I formerly conveyed to you a little information which I have since received, and some views which I entertain in regard to the future of this question. In the first place, the great dominant difficulty is, and has been, the want of a good harbour on the other side. The great argument on this question has been that the harbour of Calais was impracticable. Hence we have had harbours proposed on the other side. Hence we have had boats proposed to go into shallow harbours, such as Calais has been. Now I am happy to be able to inform you that the question of the improvement of Calais harbour has been under careful consideration by the French engineers ever since the month of June last. I am happy to inform you that on this subject, after receiving the most thorough investigation and careful examination by the most eminent authorities in France, a conclusion has been arrived at which I am sure you will hear with pleasure. There remains no difficulty in providing at Calais a harbour with 20ft. depth of water at low water, and maintaining the same in perfectly good condition; and as we have now at Dover 36ft. of water, and are to have at Calais, in less than two years, 20ft. of water, it is quite plain that we may now attack, as Sir Edward Belcher has attacked, the problem of having a good seaworthy ship, not one floating on the surface, but a good seaworthy ship with a respectable draught of water, and one which we may manage to give very respectable qualities to. That difficulty having disappeared, I am next asked, what is the use of sending the trains on board the ship? why cannot the passengers go on board the ship without the trains? Why put yourselves to the expense and trouble of making such enormous ships, merely to carry over the passengers without the trouble of walking on board? Very well. Now, this is very soon and easily answered. We do not build big ships at all for any such object, or with any such aim. The dimensions of our ships are not of our choosing; they are made, like other pieces of business, according to the circumstances of the case. What do you want? You want speed. Can you get speed without length? No, that is impossible. Then what length must you have to get a ship to go that distance in something like an hour and ten minutes? You all know it must be 18, 19, or 20 knots per hour. What length do you want for that speed? You all know you want very nearly 400ft. For our speed we want nearly 400ft. Then what beam must you have to make a decent ship 400ft. long? Perhaps you will say 40ft.—that is a tenth part—that is not too much beam. Very well, I accept your 40ft.; 40ft. of beam, then, and 400ft. long, is necessary to make the fast and decent ship we want for speed alone and seaworthiness alone. Now, there is the ship built for me. I do not make the dimensions of the ship—I do not choose the dimensions of the ship. Now I have got this big ship. Such ships, not so large, but exquisitely beautiful ships, which I have always regarded as the pride of the naval architecture of England, have been built under the auspices and by the hands of some gentlemen whom I see here, for a similar passage, only a bigger one, namely, between Holyhead and Kingstown. Now there they do not take any trains, and yet they have got very big ships; not quite so big as I have said, but very big ships. Why did they make those very big ships, having nothing to do with the trains? Because they wanted speed, and they wanted seaworthiness. Why do they do not take the trains? My friends think they have me there; there are big vessels, good vessels, and everything we desire, and they do not take the trains. No, they do not take the trains. Do you know why they do not take the trains? I don't think you do. I don't think anybody does. I did not until I looked into it, and then I could hardly believe it when I found it out, that the British nation—that the British legislature—had made such a beautiful blunder—may I say such an Irish joke—that if you took a train and locomotive engine to-morrow on your steam packet across to Ireland, there is not an Irish railway on which they could run, for they made the mistake in making the Irish railways not to fit the English trains, so that neither locomotive engine nor carriage, nor anything in England, taken over to the other side, could possibly go along an Irish railway. It is, therefore, of not the slightest use to send over a train to those railways, because they could not move a mile. I dare say I may be wrong as to one railway, because I think there was a dear old atmospheric railway which was on the national gauge, but I am not quite sure. All I know is, that the standard gauge on the Irish railway is such that no English train can go upon it. It was obtained in a very curious manner. There was a discussion between wide gauges and narrow gauges, and a very wise engineer, whom I respect and love very dearly, was asked to find out the proper gauge. So he said he thought the proper gauge would be to add a narrow gauge and a very broad one together, and divide by two, and it came to 6ft. and some unknown number of inches, and that was the Irish gauge. I think one was 6ft. 2in., and the other 6ft. 8in.

Mr. Oliver Byrne—Five feet four inches.

Mr. J. Scott Russell—It is the mean of some gauge. Allow me to tell you what I believe to be the enormous advantage of carrying trains over in ships. Not the saving the passengers from walking on board—not the saving of them going out on the other side, but the saving of poor bundles of merchandise from being taken out of a railway train, tumbled into a ship, hoisted out of the ship on the other side, repacked in wagons, and then sent forward after wonderful damage, wonderful delay, and no end of cost, to their destination. Of the enormous heavy traffic between England and the Continent, scarcely any passes over the ferry between Calais and Dover, though so many railways go down to both sides of the Channel; and the reason is the damage, delay, and expense of the whole transhipment between the two countries. There is the question. That is what renders it a most economical question, for it will cost less to carry over a ton of goods in those big, expensive boats than it will to perform the whole transhipment from the railway to the ship, and from the ship out to the railway station on the other side. That is the key to the whole question; and, believe me, when the mines of iron, and mines of coal, and manufactures of this country are put into such continuous connection with the whole countries of the Continent, that ten tons of goods placed on a wagon in any part of England or the English railways will not leave that wagon, or be disturbed till those ten tons of goods are delivered in Austria, or in Belgium, or in Germany, or in France —believe me, when that day comes, the amount of intercourse by railway between England and the Continent will be something of which at the present moment we have very little conception. Now, gentlemen, that is the great good to be achieved. It is quite true that the other is a good way, which we shall all value. We shall be delighted to get this convenient arrangement, we shall be delighted to take our place in the carriage, and not to be disturbed until the same carriage arrives with us at our destination on the Continent, because I do not imagine that the railway trains will stop short at Paris. I imagine that you will take your seat in a train in London, and that you will not be disturbed until you have arrived at whatever very large town you want to reach on the Continent.

Permit me now to say how I think the greatest convenience to passengers will be obtained. If my friend's and our views are ultimately carried into effect, we shall have what is called an American train for night passengers. An American train consists of two long ranges of cabins, like the cabins of a steamship. There are several saloon carriages also connected with it, in which you have conveniences and comforts of which we have never dreamt, in this country, in our trains. In these American trains this will happen. We expect that the time of our transport will be reduced, from Paris to London, to eight hours. We shall propose that a night train will leave London at ten o'clock in the evening; that at ten o'clock you will go to bed, that you will not be disturbed at Dover or at Calais, or till you get to Paris at six o'clock in the morning. At six o'clock in the morning, you will be awakened, before you get to Paris, in order that you may wash and dress, and make yourself extremely comfortable, and by the time you have done that the train will be in the Paris station, and you will walk out. That is our plan, and I believe that those who have the most experience in being sea-sick—I am sorry to say, not being subject to sea-sickness—I cannot give you any results from my experience, but those who are liable to sea-sickness assure me that one of the best antidotes is to go to sleep on a kind of hollow circular bed, which does not let you feel the change of level, to keep your eyes shut, and to stay in bed till you get across. I believe that is considered to be one of the best antidotes, although I am sorry that I have never been ill enough to give you a decisive opinion on the subject. Permit me to add, also, that in the particular vessel which I have shown you there is no hydraulic machinery, there is no mechanism of any kind employed to put the train on board. What happens is this. The locomotive never comes down with its train. In the last station it has been shunted to the other end of the train. It simply comes down after its train, and, without the slightest delay, runs the train on board. There is no stopping, no elevation, no depression.

Mr. Samuda—Is there no alteration with the rise and fall of the tide?

Mr. J. Scott Russell—Yes, there is 20ft. rise and fall in the tide, and there is a very long, gentle inclined plane, which enables that difficulty to be surmounted. It simply then runs the train on board the ship, and on the other side the wagons arrive and are taken off, so that there is not the even the delay of a second at either end. The moment the ship is at its place the wagons are attached, and at that moment away goes the train. Now, with regard to expense, I have one word to say. I have not yet mentioned to you that in the large ship, as I have already done in the little ship, I have two trains parallel to each other. You will allow me to say that each ship takes two trains of from sixteen to seventeen wagons each; and as to those two trains, I wish merely to state this to you, that the expense of carrying them across in these ships is not so much greater than the expense of carrying so many tons of freight, according to the returns I have of the working of this ship of the larger build for the last twelve months. One word more, and I have done. I believe the only difficulty in reference to money is not the expense of the ships or of working them, but I believe the real point is this:—Dover harbour is the property of the government; Calais harbour is also the property of the French government. I believe if the two governments lay their heads together, and simply make their harbours accessible—as I have said to you, they now can be made at a very moderate expense indeed to the two governments—a great international communication can be easily established. Permit me to say one word in regard to the competition of railway train ships with the other plans proposed for the communication between Calais and Dover. All I have to say is said in one word. The advocates of the train steam ships are neither opponents of the tunnel under the earth, nor of the tunnel in the water, nor of the bridge in the air. They are perfectly satisfied to put the public into possession at once, within less than two years from this date, of this improved communication, and then to allow the other systems which may be adopted—say the tunnel system—to go on until they are completed. We believe it will take so much time and so much money to complete any of these other systems, that we shall have done our work and created the traffic before the others are ready to take it from us when we shall be delighted to resign it, and that is the whole thing.

ON STREAM-LINE SURFACES.

By W. J. Macquorn Rankine, C.E., LL.D., F.R.SS., London and Edinburgh.

1. The object of this paper is to place before the Institution a summary of the principal results of a mathematical investigation, of which the details have been communicated to the Royal Society. A *stream line* is the path that is traced by a particle in a current of fluid. If the current is steady, each individual stream line preserves its figure and position unaltered, and marks the track of an *elementary stream* of fluid. The motions in different parts of a steady current may be represented to the eye and to the mind by means of a group of stream lines; for the direction of motion of a particle of fluid at a given point, is that of a tangent to the stream line which passes through that point; and when the fluid is a liquid such as water, the comparative velocities of the current at different points are indicated by the comparative closeness of the stream lines to each other.

2. A *Stream-line Surface* is a surface which traverses an indefinite number of stream lines, or, in other words, a surface such that every stream line which traverses a point in that surface is wholly situated in the surface. We may conceive a current to be divided by an indefinitely great number of steam-line surfaces into elementary streams; and then the velocity of the current at different points in the same elementary stream will vary inversely as the area of transverse section of that stream, measured on a surface which cuts the stream lines at right angles, and the component of that velocity, in a given direction, will vary inversely as the area of a section of the elementary stream made by a plane perpendicular to that direction; also, if the dividing stream-line surfaces be so placed that equal masses of liquid flow in equal times along the elementary streams, the velocities at any two points in the current will be inversely proportional to the the areas of transverse section of the elementary streams at those points.

3. When a current is represented on paper by the help of stream lines, the surface of the paper represents one of a set of stream-line surfaces; and the stream lines on the paper represent the trace, on that surface, of a second set of stream-line surfaces, so placed that the two sets of surfaces divide the current into quadrangular elementary streams of equal flow. A pair of adjacent surfaces belonging to the same set, contain between them what may be called an elementary layer of the current, and this is divided into elementary streams by the other set of surfaces. If the layer, of which the paper represents one surface, is of uniform thickness, the velocity at a given point varies simply in the reverse ratio of the distance between the stream lines shown on the paper, and such is the case when problems in two dimensions only are considered; when the layer is of unequal thickness, that velocity varies also in the inverse ratio of the thickness of the layer, and such is the case when problems in three dimensions are considered; for example, in problems relating to stream-line surfaces of revolution, a straight line on the paper represents the common axis of a set of such surfaces; the paper represents a plane stream-line surface traversing that axis, and the thickness of the layer at any point is proportional to the distance from the axis.

4. *Straight Currents.*—A straight current of uniform velocity is represented by a set of parallel straight lines. If the layer is of uniform thickness, these lines are equidistant; if its thickness varies, the distance between a pair of adjacent lines varies inversely as the thickness of the layer. A current diverging or converging in straight lines from or towards an axis or a point, is represented by a set of straight lines radiating from or towards the point or the trace of the axis. When the layer is of uniform thickness, those radiating lines make equal angles with each other; when it is contained between two planes cutting each other in an axis, the radiating lines represent the traces of a set of conical surfaces with a common apex, so placed as to cut a spherical surface described about that apex into zones of equal area.

5. *Composition of Stream Lines.*—If two sets of stream lines be drawn so as to represent two different states of current motion in the same layer of liquid, a third set of lines drawn diagonally through the network formed by the first two sets will be the stream lines representing the resultant state of current motion in the same layer arising from the compounding of the actions which would separately produce the first two states. This proposition is due to Mr. Clerk Maxwell; and by its aid stream lines representing current motions of any degree of complexity may be drawn. Amongst algebraical investigations of the kind of motion which stream lines represent, reference may be specially made to those by Mr. Stokes (Cambridge Transactions, 1842 and 1850).

6. *Motion of a Liquid past a Solid.*—If a solid body is of such a figure that a current of liquid flows past it smoothly without forming eddies (others than those produced by friction), the surface of that body is itself a stream-line surface; and it may be proposed to determine, as a mathematical problem, either what forms of surface possess that property, or whether some given form of surface possesses it, and if so, what are the figures of the stream lines in a current of liquid produced by a solid of that form. The latter problem has long ago been solved for an indefinitely long circular cylinder, with a current flowing past it tranversely; and for a sphere, it was solved by Dr. Hoppe in the *Quarterly Journal of Mathematics* for 1856.

7. *Application of Stream Lines with one pair of foci to forms of Ships.*—If a ship is capable of gliding smoothly through the water without forming eddies, other than those produced by friction, her surface is a stream line surface. In a paper read to the Royal Society in 1863, and printed in the *Philosophical Transactions* entitled "On Plane Water Lines in Two Dimensions," the author investigated the figures and properties of a very numerous class of stream lines belonging to the motion of a current in a plane layer of uniform thickness, whose forms closely resemble those of actual ships of a great variety of models and proportions. Elementary rules for drawing such lines are given in a work entitled Shipbuilding, Theoretical and Practical, published in 1866-7. In a paper read to the British Association, and printed in the *Philosophical Magazine* in 1864, he extended similar methods to stream line surfaces of revolution. The general nature of the method of finding stream-line surfaces suited for the figures of ships may be summed up as follows: The ship is conceived to be stationary, and the water to move astern with a velocity whose undisturbed value is equal and opposite to the speed of the ship. The uniform current thus conceived to exist in the water is represented by a series of parallel straight stream lines; then, to represent the disturbance of the water produced by the vessel—which consists in a pushing aside of the water by her fore-body, following by a closing in of the water behind her after-body—stream lines are drawn, which diverge from a point in the fore-body and converge again towards a point in the after-body. These points are called foci. The parallel straight lines representing the uniform current, and the curved lines representing the disturbance, form a network; and through the angles of that network lines are drawn diagonally, which are the traces of the required stream-line surfaces. The lines thus obtained closely resemble the water-lines, riband-lines, and other longitudinal sections of ships of a great variety of forms and proportions; and there is scarcely any known figure of a fair longitudinal line on a skin to which an approximation may not be found amongst them. They have, however, the following defects: First, amongst each set of stream lines there is only one that is a continuous closed curve, accurately representing the form of a solid that can glide smoothly through the water; and that one is always a very bluff-ended oval, and therefore suitable only for the lines of a slow vessel. To obtain amongst stream lines, with only one pair of foci, a curve resembling a longitudinal line of a ship of a fine model, suited for high speeds, it is necessary to make use of the middle part only of a stream line which extends in both directions indefinitely far, so that there is discontinuity of form and of motion at both ends of the curve employed. Secondly, stream lines with only one pair of foci are incapable of representing the forms of those models shaped like swimming water birds, from which Mr. Froude lately obtained favourable results in his experiments.

8. *Application of Stream Lines with two or more pairs of foci to Forms of Ships.*—Those defects are overcome in the investigation to which the present paper relates, by using two or more pairs of foci of divergence and convergence. By this method can be obtained continuous closed stream-line curves of any required proportion of length to breadth, and of any required degree of fineness at the ends; the only difference between them and the actual longitudinal lines of ships being, that the stem or cut water is rounded in the theoretical curve instead of being squared off as in the actual lines. By suitably arranging the foci relatively to each other and to the ends of the curve, and by introducing a third pair of foci if necessary, any degree of fineness or bluffness, hollowness, straightness, or convexity may be given to the lines, and any required breadth to the stem.

9. *Empirical Rule for Displacement.*—The following empirical rule for a rough approximation to the displacement of a solid bounded by a stream line surface, is an extension of a rule first published in the treatise on shipbuilding already referred to. It has been verified by trial on a great variety of figures.

Multiply the area of midship section by five-sixths of the longitudinal distance between that pair of cross sections whose areas are each equal to one-third of the area of midship section.

10. *Dynamical Investigations.*—The chief practical use of investigations of the figures of stream lines is not so much to find methods of drawing these lines for purposes of naval architecture, as to enable rules to be laid down for making dynamical calculations respecting the disturbances in the water produced by vessels to whose figures these lines present approximations. The investigation now referred to shows how to determine the ratio borne by the energy of the disturbance in the water to the energy due to the motion of the vessel, in every case in which a stream line surface can be determined, which sufficiently approximates to the form of the vessel. That ratio is found to range from ½ to 1, and such is the ratio borne to the work employed in producing a given acceleration in a given ship, by the additional work required in order to produce the corresponding acceleration in the disturbance of the water. The dynamical properties of stream lines also enable us to determine the virtual depths to which various parts of the disturbance extend, upon which depths depend the velocities and positions of various series of waves raised by the vessel, and the velocities of gliding of the particles of water over different parts of the ship's skin, upon which depends the friction.

ON LIQUID OR CONCENTRATED FUEL.

By Captain J. H. SELWYN, R.N.

In continuing the subject of liquid fuel before the Institution of Naval Architects this year, I wish to draw attention specially to the value of the principle of concentration which is involved in the use of such a combustible. I have therefore headed the paper with a double title, of which one part refers to the liquid condition of the fuel, the other to the fact of its being highly concentrated. Since I last addressed the Institute on this subject I have continued the experiments on which I was then engaged at Woolwich up to the time at which the closing of that yard put a stop to them. I hope to see them resumed and carried to a legitimate conclusion; but I cannot go to much expense myself, and so little is now allowed to be expended, even on the most useful experiments, by the Government, that it is extremely doubtful when the authorities will consent to do what would inevitably save many thousands of pounds to the nation were it done. In order to convince you that I am not overstating the economy to be expected, and the convenience that may result from the further experiments which I advocate, I will now, after a short recapitulation, place before you the facts on which I ground such an opinion. I showed in my last paper that the chemical analysis of the oil used entitled us to expect that its theoretic calorific value—that is, the number of pounds of water one pound of the oil I used might, theoretically, be expected to evaporate—would be 17·5. I also showed that in a trial at Woolwich in the Oberon boiler, in which economy was the sole object, and quantity was ignored for the time, 16·9lb. of water were evaporated; and although the quantity used in a boiler of 1,705 square feet of heating surface was then only about 60 cubic feet per hour, I assure you that this was only because no more oil could be burned in that trial, on account of an insufficient supply of steam from the small boiler which served the injectors. The trials were continued, with such alterations as were found to be productive of good results, from April to July, 1869; and at the latter date we have succeeded, by a gradual amelioration, and by taking the steam for jets from the large boiler itself, in increasing the quantity to 236 cubic feet per hour, with an economy of 14·9, after deduction of the water or steam used in the jets. But at this point of my observations I must entirely refuse to concur in the propriety of any such deduction being made, and this for two reasons. First, because from the experiments of Bunsen and Tyfe—names which command the highest confidence among chemists of all nations—it appears that red-hot coal "and aqueous vapour mutually decompose each other into hydrogen and carbonic oxide gases, with some carbonic acid, both of which, if sufficient oxygen be present, burn with the production of a white heat, to form water and carbonic acid, and that numerous observations showed, further, that the additional heat evolved more than compensated for the fuel used in producing the vapour." Secondly, because, as you will see from the tabulated form—which is official, except where special figures are shown—at a time when 16·1lb. of water were being evaporated by the use of each 1lb. of oil, the theoretic calorific value being 17·5, the temperature of chimney, or that of the escaping gases was 680 deg. Fah. Now, according to one of Professor Macquorn Rankine's formulæ, 680 deg. Fah. corresponds, under the conditions, to a loss of 2·7 pounds of water vaporisable. Now, deducting the evaporation actually obtained, namely, 16·1 from 17·5, the theoretic ultimate calorific effect of the oil, we have 1·4, which might possibly be due to the oil; but how shall we account for the other 1·3 of heat in the escaping gases, unless we allow that this is a corroboration of Bunsen and Tyfe's observations, and that, consequently, the water used in jets ought not to be deducted from the total evaporation of water from the constant of 212 deg. feed. At any rate, I think it fair to show you what would be the results if this be the right view, and you see the special figures showing 254 cubic feet evaporated per hour at the rate of 16·1 lb. for every pound of fuel consumed. As this is done with a boiler whose total heating surface is 1,702 square feet, it amounts to a cubic foot of water evaporated per 6·7 square feet of heating surface, with an ordinary tubular marine boiler, situated on a cold wharf, and only partially lagged or covered with felt. This duty was performed by the boiler with the ordinary arrangements of fire bars, ashpit, and fire doors, and there was nothing to prevent coal being burned the next hour or at the same time if required. The experiments with the fire-brick combustion chambers built in the ashpits did not turn out to be superior in results to those done as above, and as such an arrangement necessitates the use of a small auxiliary boiler to raise steam in any moderate time they were discontinued. This, however, might not be the case with a different type of boiler. I am of opinion that results above described might yet be beaten in the same boiler if a higher class of oil and more steam were used: but, as it was, I was obliged to be careful, since even with a large steam pipe open, besides the jets, the safety valves were not always able to prevent the pressure rising beyond the 24 lb. at which we were working. It was, of course, necessary then to shut off some of the oil, which is done by a mere touch. It will be remembered that while with coal no more than a certain number of pounds can be placed on the grate so as to burn, there is no other limit to the quantity of oil that may be burnt than the supply of steam to the injectors, or in a short boiler the loss of heat up the funnel. As regards safety, there is no longer the slightest doubts on the minds of those who use this fuel. The oil only differs from ordinary train oil in this particular, for the reason that train oil would float on, but this oil sinks under salt water. It is, therefore, less liable to accidental combustion, and more easily put out, should it ever inflame when substances are thrown into it that may act as wicks. A white-hot fire-brick may be plunged into the oil with the most perfect impunity. If shavings are thrown in and set on fire these form wicks, and the oil burns as train oil would do, but water will instantly extinguish even this; in short, I confidently state that all idea of danger may be dismissed, at once and for ever, with an oil whose specific gravity is 1·050 and upwards.

I can only account for its not having already come into general use as fuel by three considerations: First, the prejudices which invariably retard new applications of knowledge; secondly, the attempts of holders to realise high prices before the economies derivable have become fully known; and, thirdly, because several persons have thought they could do without those who had studied the question, and have, therefore, only succeeded in burning the oil wastefully.

I am satisfied that there is an ample supply of material from which the oil can be obtained at a remunerative price; that ship-owners can well afford to give from £2 to £3 a ton for it when they know its use thoroughly; and that it is at this moment cheap to use it at the 30s. per ton of 213 gallons, which is asked for it, seeing that one ton of it—used without stoking, be it remembered—is equal to two tons of coal in evaporative duty, and that that ton only takes 36 cubic feet of space instead of 92 cubic feet, which two tons of coal would occupy. If, again, every drop of the oil does its work, while there is a large proportion of ashes and slag in the coal—if, I say, these and other economies not so apparent, but still important, are to be considered as they deserve—then no long time ought to elapse before it is brought into use in our commercial marine.

But, of course, I am more especially anxious that our navy should profit by it, and what I now desire is, that having proved so much in a steam launch first, and then in an ordinary marine boiler on the wharf, the next step should be taken of fitting it in a gun vessel of moderate size, whose performance is already well known, in order to test it fairly at sea, and to estimate accurately what may be the subsidiary economies that attend its use there in order to know what prices can be given for larger quantities when required. Then the condensation of which I spoke will take place as an ordinary fulfilment of the law of supply and demand; the light spirits and other products, including illuminating oils, will find their proper market, and the distiller of such will no longer consider so large a proportion of his distilled products as mere waste, unsaleable any any price. This was, I am informed, the case at Wareham, near Poole, where the distillation of shale (forming cliffs along that coast) was once carried on with a result of fifty gallons of crude oil to the ton of shale, or Kimmeridge clay.

This distillation was voted a nuisance by the inhabitants, as it was attended by a very disagreeable smell, which was, however, solely due to the fact that the distillers did not then provide means of burning these gases under the stills as they might, and ought to have done, with considerably increased economy in the production.

I believe the process established at Chatham by Messrs. Dorsett and Blyth for heating armour plates, &c., by liquid fuel is still carried on there with admirable results. Mr. Barnes, of Victoria Park, also continues to speak highly of the apparatus of Messrs. Wise, Field, and Aydon, fitted to his steam boiler, and I know that some mercantile men are anxious to fit it in their steamships as soon as practicable.

It is essential to the proper burning of this oil that it should not, while entering into combustion, be cooled down in any way, and a mass of fire-brick, slag, or other rough material on the fire-bars forms a very good heat governor; but the ashpits and fire-doors ordinarily fitted are decidedly not the best that we could have. Some flame—as a piece of lighted wood or cotton waste—should always be in the furnace when turning the oil on. The existing form of injector can scarcely be improved on, excepting in very large furnaces, where they ought to be double. In some cases the oil may be sucked up from tanks placed below the boilers by the steam that burns it. The higher the pressure, and the drier the steam, the better. Superheated steam is always preferable for the jets, and this should be made in the chimney where the heat passing off is otherwise clear waste. Joints for the oil should be made with lime and glue; no red lead joint is of any use. As little water as possible should be allowed to mix with the oil, otherwise the fires are soon put out, though the water will always keep at the top of the oil unless much agitated. The raising steam in all these last experiments was done as in an ordinary coal boiler, and the steam when raised was taken to the injectors from the large boiler itself.

Sweeping of tubes or cleaning of flues was never necessary from November, 1868, to July, 1869. I have now only to draw your attention to the tabulated results and to request you to recollect my statement of last year, that the means obtained with this boiler on trial in a stoke-hole, whose temperature was 95 deg. Fah., with best steam navigation coal, were 8·2lb. of water evaporated per lb. of fuel, and 206 cubic feet of water per hour, both calculated from the constant of 100 feed, which I do not approve, as it takes no account of the latent heat and does not give any real estimate of calorific power comparable with the chemical analysis of the fuel experimented with. I have now fulfilled the promise of further information made by me at your last session, and while I feel grateful to the Admiralty for enabling me to carry on the experiments so far, and to those who have contributed in various ways to take a portion of the burden of them from my shoulders. I feel also that it is my duty not to relax my efforts to get the investigation continued, and still more light thrown on the question, and in the hope that I shall succeed in these efforts I renew my promise, if all be well, of another communication in continuation of the subject for the session of 1871.

INSTITUTION OF CIVIL ENGINEERS.

ON THE STRENGTH OF IRON AND STEEL, AND ON THE DESIGN OF PARTS OF STRUCTURES WHICH CONSIST OF THOSE MATERIALS.

By. Mr. George Berkley, M. Inst. C.E.

The author stated that the strength of wrought iron varied with the quantities of work involved in the production of the form of the material tested. This was proved by the fact, that a bar of iron 1in. square, which would break with a strain of 26 tons, would, if drawn down to the form of wire $\frac{1}{32}$ of an inch in diameter, bear a strain of 40 tons per square inch. The strength to be relied on in practice would probably be best represented by the minimum strain that 1 square inch would bear without rupture, and by the amount of stretch which would take place in a given length before it broke. Iron could be obtained, at the current market rates, which would bear the following strains:—For plates, an average breaking strain of 20 tons per square inch, and a minimum breaking strain of nineteen tons per square inch, and an average stretch of 1in. in 12in. lineal. For L and T irons an average breaking strain of 22 tons per square inch, and a minimum breaking strain of 21 tons per square inch, and an average stretch of 1¼in. in 12in. lineal. For rivet iron an average breaking strain of 18 tons per circular inch. For bars intended for chains, couplings, &c., an average breaking strain of 22 tons per square inch, and an average stretch of 1⅝in. in 12in. lineal. For ordinary classes of work, let at competitive prices, stronger iron could only be obtained with difficulty.

In the consideration of the practical limit of strain to which 1 square inch of wrought iron could with safety be subjected, and the principle on which such a limitation rested, the erroneous impression, as to the degree of strain being 10 tons or 12 tons per square inch which first produced "permanent set," was pointed out; as well as the apparent discrepancy between the results of ordinary observation and of minutely manipulated experiments, such as those of Sir Wm. Fairbairn and Mr. E. Clark, was noticed, wherein permanent set had been observed after 3 tons per square inch had been imposed on the iron, and was explained by the difficulty of registering such small amounts of set as $\frac{1}{1250}$th part of an inch in 5ft., which resulted from a strain of 10 tons per square inch.

Attention was drawn to the fact, that upon the application to 1 square inch of wrought iron of strains exceeding about 12 tons, the measure of stretch per unit of strain, which had previously increased in a certain proportion to the units of strain applied, increased with a greater and progressive rapidity. It was also noted, that the amount of stretch, actually produced by the imposition of a strain of about 12 tons per square inch, would be sufficient frequently to preclude the use of wrought iron so strained.

In illustration of the effect of the repetition of strains on iron and steel, it was stated that with blows powerful enough to bend bars of cast iron through one-half of their ultimate deflection (that was to say, the deflection which corresponded to their fracture by dead pressure) no bar was able to stand 4,000 of such blows in succession. And also, that when the bar was thrown into a violent tremor, then "when the depressions were equal to one-half of the ultimate deflection, the bars were broken by less than 900 depressions." A piece of rail, weighing 68lbs. per yard, made of Bessemer metal, which when placed on firm bearings 3ft. apart, bore one blow from a weight of 1 ton falling through 30ft. without breaking, though bending about 7in., broke with a weight of 3¾ cwt. falling 15,400 times through heights increasing from 1ft. to 10ft. by increments of 6in. each time. With wrought iron, it appeared from an experiment of Sir Wm. Fairbairn, that when it was desired to repeat the application of strains from 2 to 3 million times it would not be prudent that such strains should exceed 7 tons per square inch of section.

It appeared from these considerations, that the practical strength of wrought iron, in structures of a permanent character, could not be estimated at more than 12 tons per square inch. when such an amount of strain was repeated more than a small number of times; and that it should not be calculated as exceeding 7 tons per square inch when strains of this amount would be applied to it many times daily. In some of the principle suspension road bridges, it was said that a maximum of about 9 tons per square inch of section in tension was imposed on extraordinary occasions, while railway bridges were frequently subjected to the maximum calculated strain, a limit of 5 tons being in this country generally adopted. From this practice it was assumed that a margin, for errors of design and for other practical defects, of only 25 per cent. was allowed in permanent structures. The importance of sound principles of design was, therefore, manifest. The parts most difficult to design were the connections of portions of the structure with riveted joints. It was desirable that the area of the section of the rivets to be sheared, as well as of the plates forming these connections, should be somewhat in excess of the sectional area of the plates or bars which they connected; and that as the process of punching the rivet-holes in the plates, &c., had a tendency to weaken them in a greater proportion than that in which the area was decreased, it was advantageous to drill all rivet-holes in parts exposed to tension. It was represented that the general principles of design were well illustrated by a joint made of a single pin, such as that used in suspension bridges, Warren girders, &c. Examples of various forms of links were presented for consideration, and a form of link of equal thickness, but with an enlarged head, was said to have been proved by experiment to be of about equal strength in all its parts. The proportions of these links were as follows:—

The bar	A	being	100
The diameter of pin........................	B	=	75
The depth of head beyond pin	C	=	100
The two sides of the pin-hole	DD	=	125
And the radius of the curve of neck ...	R	=	150

Links of these proportions, with larger pins and narrower sides—Nos. 7 and 7a—and larger pins and sides of the same width, Nos. 8 and 8a, made of iron of exactly the same strength, and links of proportions precisely similar to those adopted for the Menai, Nos. 9 and 9a, the Pesth, Nos. 10 and 10a, the Chelsea, Nos. 11 and 11a, and the Hungerford, Nos. 12 and 12a, were compared. Taking the strength of the standard form, 22·125 tons per square inch of bar area, as = 100, the per centage of gain or loss in power of resistance to ultimate strain by the use of the other forms of links was as follows:—

6 and	6A = 100				
7 „	7A = 79·9;	loss	= 21·1	per cent.	
8 „	8A = 104·7;	gain	= 4·7	„	
9 „	9A = 92·0;	loss	= 8·	„	
10 „	10A = 79·8;	„	= 21·2	„	
11 „	11A = 89·2;	„	= 10·8	„	
12 „	12A = 85·4;	„	= 14·6	„	

The necessity for strengthening the heads of links, and for testing all of them with a strain equal to at least 10 tons per square inch of bar, was proved, it was believed, by the experiments quoted, and by the evidence of Mr. Provis in his work on the Menai bridge. It was urged that an examination of the diagrams would show, that some links failed with a less degree of stress, on account of the junction of the mass of the head with a comparatively smaller section of bar, by means of a curve of too short radius. This imperfect principle of construction also operated in causing fracture across the centre of the heads on both sides of the pin-hole; and in such designs, the question of the direction of the strain being truly along the axis of the link or bar, and of the strength of the material on both sides of the head being equal, should be considered.

The author next directed attention to the unsatisfactory state of the knowledge of the profession respecting the power of struts of various proportions and forms to resist compression, and stated his belief that the formulæ which had been proposed to facilitate calculations for determining the strain which such columns would bear, produced results which neither agreed one with the other, nor with any series of such experiments as has been tried. It seemed probable that for the present error might be best avoided, by referring to the results of experiments made upon columns, &c., the conditions of which were analogous to the case under consideration.

With respect to cast iron, it was stated that a mixture of irons for sleepers had produced bars, 2in. by 1in. in section, which, when placed on bearings 3ft. apart, had on an average of 1,151 experiments during the last three years, borne 33·4 cwt. placed on the centre, and castings, 1½in. in length and exactly 1in. square, which on the average of 1,002 experiments had borne 13·07 tons of tensile strain. An attention to the amount of deflection of the test-bars had been beneficial, the average strain required to break the sleepers having been raised since the amount of deflection of the bars with a given weight had been increased. For the purpose of ascertaining the comparative strength of precisely similar girders cast with iron of varying degrees of strength, as represented by the ordinary test-bars, and when subjected to a direct tensile strain, the experiments detailed in the appendix (table No. 7), were tried, the girders being cast of the exact form and dimensions of three of those described in Sir William Fairbairn's "Researches on the Application of Iron to Buildings." The results were as follows:—

The strength per square inch of section was represented in girder No. 1 by

Mr. Fairbairn's experiments	as =	3,214lbs.
The first series of special experiments......	as =	4,977 „
The second series of „ „	as =	5,977 „

In girder No. 2 by

Mr. Fairbairn's experiments	as =	3,346lbs.
The first series of special experiments......	as =	5,284 „
The second series of „ „	as =	5,308 „

In girder No. 3 by

Mr. Fairbairn's experiments	as =	4,075lbs.
The first series of special experiments......	as =	4,998 „
The second series of „ „	as =	6,300 „

The strength of the test-bars and the tensile strength of the iron used by Sir William Fairbairn were not stated; but it might be assumed to be equal to about 25 cwt. placed on the centre of the bars, between bearings 3ft. apart, and to a tensile strength of about 7 or 8 tons per square inch. The strength of the iron employed in the special experiments was represented by a weight supported by the test-bars varying from 30 cwt. to 38 cwt., and by a tensile strength vary 10·25 tons to 13·94 tons.

In order to secure these results, the following conditions were represented as important, and should be considered in the design and execution of cast iron work:—1st. The strong iron referred to was obtained by the mixture in the furnace of four or five brands, some being harder than others. In order to amalgamate, as far as possible, these different qualities of iron, the furnace should be charged with them mixed in proper proportions in every basketful of metal which was emptied into it. 2nd. There would be a difference of about 16 per cent. between the weight that a 2in. by 1in. test-bar would support when cast on edge and proved as cast. and that which it would support when proved with the under side as cast placed at the top as proved; and a difference of about 8 per cent. between the weight the same test-bar would support if cast on its side or end, and proved on edge. This difference it would be necessary to take into consideration in estimating the strength of a large casting made from the same metal as that used in the test-bars. Another, and probably the most important practical consideration, in respect of the strength of castings, was the proportions of their several parts being such as would free them as much as possible from unequal contraction in cooling. It was not often practicable to effect that which would avoid this, viz., to adopt an equal thickness of metal in all parts of the casting; and it was therefore important that some means should be taken to prevent the castings cooling too quickly.

The author drew attention to the experiments which had lately been tried with steel—more especially Bessemer steel—which experiments he considered justified the adoption of the following conclusions:—1st. That Bessemer steel would bear before rupture a minimum tensile strain of 33 tons per square inch of section and stretch about 1in. in 12in. of its length. 2nd. That the same material would bear either in tension or in compression a minimum stress of 17 tons before the extensions or reductions of length per unit of strain become irregular or excessive, as compared with those which had preceded them—in other words, before the yielding point of the material was reached. 3rd. That this material would probably contain about ·45 per cent. of carbon chemically combined with the iron. And 4th. That this description of steel, if properly made and annealed, was as uniform in quality as wrought iron, and therefore might be employed (precautions being taken to test its quality as a substitute for wrought iron), while allowing an increase of strain of 50 per cent. to be imposed upon it.

At the meeting of this society on Tuesday, the 3rd ult., Mr. Charles B. Vignoles, F.R.S., President, in the chair, eighteen candidates were balloted for, and declared to be duly elected, including 6 members, viz.:—Messrs. John Henry Eustace Hart, Acting Ex. Engr. for Government Reclamation Works, Bombay Harbour; Robert Jones, Engineer-in-chief to the Commercial Gas Company; William Moore, Glasgow; Alexander Lawrie Nimmo, Westminster; Peter Scott, Resident Engineer, Madras Railway; and Edward Baylies Thornhill, Resident Engineer, Ashby and Nuneaton Railway. Twelve gentlemen were elected Associates, viz.:—Mr. Frederick Morris Averu, Ex. Engr., P.W.D., India; Captain Francis David Millett Brown, V.C., late Assistant Principal, Thomason, Civil Engineering College, Roorkee, India; Mr. John Theobald Butler, Kirkstall Forge, Leeds; Mr. Thomas Carrington, jun., Manager of the Kiveton Park Collieries, near Sheffield; Mr. Robert Elliot Cooper, Leeds; Mr. William Frederick Crawford, B.A., T.C.D., Engineering Staff, Madras Irrigation and Canal Company; Mr. John Breedon Everard, Stud. Inst. C.E., Leicester; Mr. Robert John George, late Engineering Staff of the Delhi Railway; Mr. George Rushout Godson, Westminster; Mr. John Anthony Kendrew, Contractor's Staff, Ceylon Railway; Captain Grenville Pulteney de Palezieux Falconnet, R.E., Ex. Engr., P.W.D., India; and Mr. William Roberts, Assistant General Manager of the Great Southern Railway of Buenos Ayres.

ANNUAL DINNER.

The annual dinner was held at Willis's Rooms, King-street, St. James's, on Wednesday, the 4th of May, the President, Mr. Charles B. Vignoles, F.R.S., being in the chair.

The company actually present included the following guests:—Sir Frederick Arrow, General Balfour, Mr. A. J. B. Beresford-Hope, M.P., Lord Chief Justice Bovill, Mr. Baron Bramwell, the Right Hon. H. A. Bruce, M.P., Mr. George Chester, the Right Hon. H. C. E. Childers, M.P., Sir J. Duke Coleridge, M.P., Admiral Collinson, the Earl of Derby, Mr. Deputy Fry, the Right Hon. G. J. Goschen, M.P., General Sir Hope Grant, G.C.B., Earl Granville, K.G., Admiral Sir John Hay, Bart., M.P., Sir Francis B. Head, Bart., Sir Henry Holland, Bart., F.R.S., Sir John Karslake, Q.C., Mr. G. Shaw Lefevre, M.P., General Napier, Professor Owen, F.R.S., Lord Alfred Paget, Sir John Pakington, Bart., M.P., Mr. J. E. Saunders, Professor Tyndall, F.R.S., Professor Williamson, F.R.S., and the Lord Archbishop of York.

Honorary Members—F.M. Sir John Burgoyne, Bart., G.C.B., and Viscount Halifax, G.C.B., together with about 150 members and associates.

The demand upon our space prevents us from giving *in extenso* all the interesting speeches that were made, but the following is a condensed account of the post prandial proceedings.—

After the usual loyal toasts,

The President rose and said—The next toast, my lords and gentlemen, I have to offer is one in which I individually am personally interested—in fact, to a certain extent, I am proposing my own health—but it is also one which we, as an institution, find ourselves so much bound up with, directly and indirectly, that I am sure you will feel the importance of receiving it with due honour. The toast I have to submit is—"The Army, the Navy, the Militia, and the Volunteers." In proposing this toast, I beg leave to couple with it the honoured name of Field Marshal Sir John Burgoyne for the army and the other land forces, and that of Admiral Sir Edward Belcher for the navy. With respect to Sir John Burgoyne, I scarcely dare trust myself to speak. For forty years we have been friends, and for nearly seventy years we have been brother-officers. Sir John, as you are aware, has arrived at that eminence in the military profession which bears his mark and record upon it; and all his friends must rejoice at the high position he holds therein. You are aware of the intimate manner in which the army has been connected with engineering by the combination of science with practical art, as illustrated by the improvements which have taken place in artillery, through the labours of our friends and fellow-members, Sir W. Armstrong and Sir Joseph Whitworth. With regard to the Army, therefore I have made out a case; and as respects the Navy, a link between us has been established by the transformation of our ships from wooden to iron vessels, in which I may be permitted to say, I think engineering science has had some part. As to the Militia and the Volunteers, with each of which many of us are connected, their value and importance to the country is universally acknowledged, and, therefore, I have great pleasure in proposing the toast of "The Army, the Navy, the Militia, and the Volunteers," associating with that toast the names of the two distinguished officers I have alluded to.

Field Marshal Sir John Burgoyne, G.C.B., said—In returning thanks for the army, I would merely say that I feel it a great honour to be a soldier; and in this special company, I think I might venture to add, I regard it as a more particular honour to be an engineer-soldier. It is impossible to deny that the engineering element is of great importance in warfare; and, assuming that to be the case, we are about to increase its importance in a very great degree by the novelties that affect war in the present day—I allude to the improvements in rifles and artillery, and other implements and devices of war that are every day coming before us from all parts of the world; and of which the engineers have more particulary to deal with than other branch of the army. I would say there is no portion of the civil community which ever gave such assistance to the military arm of the country as the engineers; and it is very satisfactory to find how readily they come to the task by volunteering, and in such numbers enrolling themselves in a most valuable corps, to add to the defensive powers for the protection of the country.

Sir Edward Belcher said—In rising to return thanks for the profession to which I have the honour to belong, I must advert to the fact that time was when engineers dealt only, as was supposed, with bricks and mortar; but the establishment of the Institution of Naval Architects has shown us how much the labours of the engineers have influenced naval tactics and construction. We are much indebted to the engineers for this deviation, thus leading the way, and gradually giving us our present iron-clad ships; but one of the principal workers in this matter has been overlooked—viz., Mr. Reed—to whom we are very much indebted; first, as the Secretary of the Institution of Naval Architects, and now, as the Chief Constructor at the Admiralty. When I first heard that we were to have iron-clads, I presumed we were to have ships covered with iron a little above the water line, and that we were to fight as it were behind stone walls. I still think it advisable to arm our ships with two or perhaps four guns that will answer all purposes, and do away with that immense amount of iron which you are obliged to carry on the upper works of our ships.

The President again rose and said—Hitherto I have not been out of my element when I had to speak of engineering and the cognate professions in which we all take so much interest; but now I have to trespass upon a domain which has almost always been proscribed upon occasions of this description. I recollect that some years past it was quite forbidden to touch upon or speak of politics, and yet I find a toast has crept in amongst those usually given, which has created a certain amount of embarrassment to us old stagers. At the same time it is a toast in which I feel individually great interest, and I am sure all who have come into contact with her Majesty's Government will feel it is correct that there should be proper recognition of them on our part. Wherever the interests of the country, or any portion of the country—and especially wherever the interests of those who have done their best in contributing to the prosperity of the country—are at stake, her Majesty's Ministers, of whatever shade of politics they may happen to be—Tory, Conservative, or Liberal—all unite, and have ever united, in supporting the honour of the country, and in carrying to a successful issue those measures in which we are all interested. I beg to propose "The health of her Majesty's Ministers," coupling with that toast the name of Lord Granville, of whom I would say, if I might take a particular example of a model Minister, I should choose Lord Granville.

Earl Granville—Mr. President, my lords, and gentlemen, I beg to return you thanks for the great honour you have done to my colleagues, present and absent, and to myself, though spoken of in terms by the President which I cannot admit. I quite understand the sense in which this toast has been proposed. I know that in a mixed assembly like this, of different politics, there is not the slightest intention in proposing and receiving this toast, of pronouncing any opinion upon individual governments. We have heard from Sir John Burgoyne and Admiral Sir Edward Belcher—competent persons to give an opinion—how much assistance the engineers are capable of affording to the government, and therefore to the country, in time of war. I trust, however, it will be in the peaceable preparation for war, and not in the practice of war, that we shall receive that assistance. In time of peace it would be idle for me to refer to the assistance they are to the Government and the country. It would be idle to repeat the feats of the civil engineers of this country during the present century, or during the last fifty or twenty-five years, simply for the reason that you know what those exploits are better than I could state them myself. But there is one thing I would say on an occasion like this—that not only am I myself a maker of bricks, to which Admiral Belcher seemed rather to allude as the only fitting subject to which you ought to attend, but as an ironmaster, as a coalmaster, and, even as a manufacturing engineer, I fully share in the hopes which I venture to express to you—that after some years of singular depression, the engineers are about to enter upon a period in which they can apply their skill, energy, and knowledge, by their power over the air, water, and fire—above and below and upon the earth—over, and through, and under the water—to bind together the nations of the whole earth to the infinite advantage, not only of their own country but of all mankind.

The President—I have to appear again before you, and you will be glad to hear it is for the last time; but this occasion on which I have to propose a toast, is one in which we, as engineers, feel particularly interested. There is a proverb of some foreign nation that it is good to propitiate evil deities, but I think we should rather attend to the worship of the "Dii majores." My toast is that of "The Houses of Lords and Commons," coupling with the toast the name of the Earl of Derby, as the representative of the House of Peers, and that of the Solicitor-General in connection with the House of Commons.

The Earl of Derby—I have great pleasure in returning thanks on behalf of that branch of the legislature of which accident and the constitution of the country have made me a member. Whether we are or are not worthy to be accounted amongst the powers of evil to whom the President, with commendable prudence, announces that he pays his respects—or whether we may be classed amongst influences less formidable and less noxious to mankind, I will not myself disclaim whatever share of responsibility devolves upon me as having very often taken part in Parliamentary committees before which engineering matters are discussed. I, however, do not altogether agree with the account which the President gave of those inquiries, because I think it more commonly happens that, instead of brow-beating on the part of the legal gentlemen, the engineers do with the committees pretty nearly as they please. I do not know that I can claim for the House of Lords that it has any close connection with the noble profession of engineering—though I do know this—that if it happened to be our fate to travel as a body by a railway, and if the locomotive broke down, there are two or three members of our body who, with the proper appliances given to them, would be quite able to set it right with their own hands. But thought our work lies in a different direction, still I think we may say, we have had something to do with the industrial and engineering history of the country. You cannot deliver a lecture upon the steam engine, in which there shall not be mentioned the name of Lord Worcester. You can hardly tell the story of the iron industry of this country without some reference to the family of Dudley. You cannot speak of inland navigation without giving due to that Duke of Bridgewater, to whose perseverance amidst many difficulties and many obstructions is mainly owing the development of the canal system of this country, and, in a great degree, the present position which Manchester and Liverpool now occupy. I do not know how it is or why it is, but undoubtedly men learnt to fight one another in the field, and to outwit one another at the bar, long before they set their minds steadily to establish communication over every part of the world, and over the sea, and to search into the earth for the treasures there contained. It would seem as if, in point of date, the combative energies of men displayed themselves earlier than those which are directed to industrial and co-operative ends. And so it has happened that the House of Lords, which is in a certain sense a record of the history of this country, contains on its roll some eighty names placed there by success in the profession of the law, and possibly as many which are due to naval or military distinction, while those who owe their position among us to an industrial career are still comparatively few. Yet there are some names—I may cite those of Belper and and Wolverton—which represent in our ancient assembly the latest components of our modern civilisation. And I say only what I think and feel, and I say it rather in the interest of the House of Lords than in that of the engineering profession, which can very well take care of itself—when I tell you that I not only hope, but firmly believe, that the next generation will see the honours of the peerage very considerably extended among those who are representatives of the industrial interests of country.

The Solicitor-General—I thank you very sincerely for the honour you have paid the House of Commons in thus receiving the toast with which you have been pleased to associate my name. I certainly could have desired that what I must venture to call the kindness rather than the judgment of the President had not associated my name with the toast of the House of Commons. Speaking to an assembly chiefly composed of scientific men, it is my painful duty to confess that, at least on political matters, the House of Commons is not very ambitious of scientific accuracy. It is not particularly tolerant of philosophers or professors. It has no tender partiality for lawyers, which all persons acquainted with that amiable profession will, I am sure, think a weakness. It is impatient of measures of which the results are necessarily distant, or, if present, are such as cannot at once be seen or felt. But, nevertheless, no man can have sat in the House of Commons, even for so short a time as I have sat in it, without conceiving a great admiration for the many high and robust and manly qualities which it displays.

Lord Chief Justice Bovill—Looking back at the illustrious names which have for more than a century distinguished the body of engineers, and the benefits they have conferred upon society, it is impossible for any one standing in this hall, as the guest of this society, not to render tribute to the genius and ability of the men who preceded you, and to acknowledge the benefits that have been conferred upon mankind at large. And in doing so, looking to the origin of this institution, it is impossible also not to connect with the benefits that have been conferred upon the country this institution, as being the source from which so many valuable discoveries have proceeded. Commencing with a small knot of men, some fifty years ago, or thereabouts, this society has gone on gradually increasing. Founded, at first, for mutual instruction and mutual assistance, it has brought together men distinguished in science, distinguished by integrity of character, by the highest genius, and by all that men can be endowed with, who have worked together cordially for the common benefit of the country, and who have diffused their knowledge and their discoveries throughout the civilised world. I believe there is still remaining at Darlington the old *Rocket*, the production of the genius of the Stephensons—a lasting memorial in metal of their genius, and which shows us the origin of the wonderful power which conveys life and property through every branch of our dominion, and every country of the world. Those who now contemplate the old *Rocket*, and see its simple form and rough manufacture can scarcely trace in it the original of the magnificent engines of the present day; instead of the *Rocket*, looking to the speed now attained by these engines, the name of Tortoise would seem to be more appropriate. And then to see the progress made by the skill and genius of our engineers in almost every branch of science that tends to the improvement of the country! to go back to the days when the *Comet* was the first steamer that plied upon the Clyde, and then to remember the magnificent steamers of this day; the ocean steamers, the men of-war, and the iron-clads, and to see the power that has been created in this way for all purposes, commercial and otherwise, almost astounds us, when we think that all this has been accomplished within the short period of little more than half a century. How is it that such things have been accomplished as that the electric telegraph should convey messages from one shore of the Atlantic to the other, but by the genius of men associated together as they were, and bringing all their intellect to bear upon one another, and so producing these magnificent results? At the present time unfortunately, from circumstances, there has been a considerable depression not only in the engineering profession but also in others; and there has been a temporary cessation only, I hope, in the exertions of their energies. I only wish that some of their energy could be directed upon the machinery of the State, and especially upon the machinery of the law. That is denied to us; but as they have contributed in so eminent a degree to the material prosperity of the country, I desire now to offer you, my lords and gentlemen, the toast of "Prosperity to the Institution of Civil Engineers.' That toast, I am sure, will be received with great cordiality in this room; but I must ask you, further, to connect with that toast one of the oldest members of this institution, Mr. Bidder, the friend and associate, I believe, of every President of the institution, and who still takes the deepest interest in its welfare. I beg to propose the toast of "Prosperity to the Institution of Civil Engineers, and the health of Mr. Bidder, the Senior Past President."

Mr. G. P. Bidder—There are only three members connected with the institution of older date on its rolls than myself; including Baron Charles Dupin, Mr. Ashwell, one of the founders of the society, and Mr. Mitchell, who was a pupil of the late Telford. I have myself been on its rolls for forty-five years. I was not one of the thirteen founders who held their first meetings over a barber's shop, but I was one of those who held their meetings in Buckingham-street, Strand, and afterwards in Cannon Row, which was not more dignified, though more commodious. I need hardly say I belonged to it when they moved to Great George-street, our present site, where we eked out our means by letting lodgings. I therefore consider that I have some right to regard myself as a link between the early stages of our profession and the position which we have now attained. We now inhabit an almost palatial building of our own. We have paid for it out of our own funds. We are not in debt; we have neither debenture nor preference stock. Our growth, I venture to say, has been only equalled by that of those of towns which we read of in the Western States of America. But to what do we owe our growth, from a few members numbered by tens, to about seventeen hundred, of all classes, besides an affiliated class of students? How have we attained to that position? I answer from the essentially democratic character of our profession. We have never been fostered or nourished. We have depended entirely upon our own energies. We had first to do battle with material Nature and its forces, and then to do battle with our fellow-men. We are somewhat like the legal profession, which may be considered the link between the working classes and the highest dignitaries of the State. Men of determined energy and talent have very often raised themselves from the lowest grade to the dignity of the House of Peers. If they have done so, it is because those men had to depend upon their own energies—not cherished, not nourished by any particular favour or power. I make these observations, because there is a feeling, I am sorry to say, in high quarters, that an engineer can be made, as it were, by machinery—if I may use the term. It will not concern me, for I have arrived at a period of life that what may happen to the profession is not likely to affect me personally, but it may affect many around me, and many who will follow them. I now beg to propose the toast of "The Visitors," coupling with it the name of his Grace the Archbishop of York.

The Archbishop of York: All of us feel grateful for the kind reception that has been given us, and for the opportunity that we have had of meeting the distinguished members of your noble profession. For my own part I am glad that it should be understood that my ecclesiastical position has in no way blunted my sympathies with all those things which affect the interests of the community We, your visitors, come here, not to taste your splendid banquet, but to visit you, because we know what you have done. Within the last half-century you have shortened the intervals of space. You have widened the earth on which mankind dwells. Last Saturday I saw a beautiful picture by that charming artist, Hook, called in the catalogue "Brimming Holland"—a picture of the sea, so full, that it appeared to be about to overspread the land, and on the edge of it were boats bearing the flowers of the garden, the fruits of the orchard, and the produce of the farm. "Brimming Holland" is all very well, but an over-brimming Holland would be a very inconvenient thing. It is your profession that has won back much of that country, and of many another, from the sea. It is you who keep the sea back from reclaiming her own. You have lengthened life, you have increased the area from which men draw their subsistence, you have ministered in a thousand ways to their comforts and convenience. And we come here to your feast, full of a sense of wonder, desiring to see the capacious brains that have designed these great works, and to know the men to whom we owe this debt.

Mr. Fowler: Mr. President, my Lords, and Gentlemen, I rise to perform the duty which has devolved upon me of proposing the toast of "Literature, Science, and Art," and of coupling with the toast the names of Sir Francis Head, Professor Tyndall, and Mr. Beresford Hope. In the exercise of our own profession of civil engineering, we have chiefly to deal with the ruder realities of life, by designing and carrying out works which minister to the daily wants and convenience of mankind. Our friend Sir Francis Head began life (like our President, Mr. Vignoles) as a soldier, and afterwards served his country with distinction as Governor of Upper Canada, but he has also been a most liberal contributor to our literature. I will not enumerate all his works, but I will mention his "Rough Notes of a Journey across the Pampas," "Stokers and Pokers," "The Defenceless State of Great Britain," "The Royal Engineer," &c. With regard to science, this is truly the golden age of science as it is of engineering, and whatever difference opinion there may as to the golden period of literature and art, there can be none as to science. When I mention the names of Tyndall, Owen, Huxley, Murchison, Lubbock, Fairbairn, Rankine, Herschell, Airy, and others, and when we remember what these men have done by their experiments and investigations, England may well be proud, as she is, of her men of science. To science and to scientific men, civil engineers are deeply indebted. The investigations and experiments of scientific men have generally preceded in due logical order the greatest practical applications of the improvements and inventions of the civil engineer. In like manner, science has contributed to the operations of war, and all works of attack and defence on sea and land are now designed and executed on the most scientific principles. Of art it is the fashion to say, and Mr. Ruskin tells us it is inevitable, that the present is inferior to that of bygone times. It may be so, and that this is inevitably an age of iron, of steam, and of utility: but I must be permitted to say that the Royal Academy, which has just been opened, presents many noble examples in the arts of painting and sculpture of which our modern artists may well be proud. It is also said architecture is in its decline. I am not prepared to admit this, although perhaps the taste and desire for grand temples and buildings on the largest scale have passed away with the age of despotism, slavery, and religious fanaticism. Fine architectural taste in public buildings is not wanting in the present day, and if need be, and adequate means were provided, I have no doubt that our modern architects would be capable of producing buildings which would rival the best and noblest monuments of antiquity. In Mr. Beresford Hope we have an ardent admirer of art. His devotion to the fine arts, and his works on art, "The World's Debt to Art," and others, are well known, as well as his great desire that all our public buildings in London should be worthy of a great people and a great city.

Sir Francis Head: Mr. President, my Lords, and Gentlemen, the word "literature," as expounded to us by Johnson, means "skill in words;" and as I well know that I am unskilled in words, it is with diffidence that I venture to submit to you a short comparison between literature and civil engineering. The works of literature, as we all know, comprehend volumes in various languages, in verse as well as prose, on subjects of all descriptions; and their growth is so continuous, that not only every spring, but every month of the year announces the birth of innumerable books, of which the best only eventually form the World's Library. Of the works of the civil engineers, they themselves may justly and proudly ask, in plain English rather than in the words of Virgil, "What region in the world is not full of our labours?" And accordingly, by the construction of arterial roads, railways, and canals—by the electric telegraph—by submarine cables, and by other innumerable works, above ground and below, they have converted what may be called "the raw material" of the earth, as it is existed in the days of its first tenant, Adam, into its present manufactured state. But, gentlemen, the cost of these works has been proportionate to their magnitude; and, I believe, it would not be an exaggeration to state, that whenever the "works of civil engineers" shall have been extended over the whole surface of the globe, the specifications of the materials required for their construction, if all linked together, would girdle its circumference. Whereas, the specifications of the whole of the materials required for the construction of all the works of literature, past, present, and future, can be enumerated by the four short words, "pens, ink, paper, alphabet."

Professor Tyndall, F.R.S.: My friend, Mr. Fowler, has referred to my visits to the Alps. I have sometimes gone there, and have found the atmosphere in a peculiar state of opalescence, which disguised the mountains. This was not due to any opaque body scattered in the atmosphere, but entirely to the brilliancy of the atmosphere itself, which so bewildered the eye, that you could not see the bodies embraced by it. By such an atmosphere do I now find myself surrounded. The name of science, Sir, covers an area of intellectual action, so large and so diverse that no one man is competent to answer for it; and, I suppose, the reason you have done me the honour of coupling my name with this toast is, that the pursuits of the engineer interlace, more or less, with those of the physical inquirer. The knowledge of nature and the progressive mastery over the powers of nature imply the interaction of two things, namely, thought conceived and thought executed; the conceptions of the brain and the realisation of those conceptions by the hand. The history of human intellect hardly furnishes a more striking illustration of this interaction of thought and fact than that furnished by the association of physics and engineering. Take for, instance, the case of steam. Without knowing its properties, the thought of applying steam could not have arisen; hence the first step was physical examination. But that examination suggested practice, and the steam-engine at length saw the light; thus experimental physics was the seedling from which the steam-engine sprang. But the matter did not end here; the positions of debtor and creditor were soon reversed. For the stupendous operations of the steam engine forced men of thoughtful, philosophic minds to inquire into the origin of the power of steam. Guess succeeded guess; inspiration succeed inspiration. The ever-present facts of our railways, and our power looms, and our steam-ships gave the mind no rest until it had answered the question, how are heat and steam, its instruments, related to mechanical power? Had the work of the engineer not preceded the work of the natural philosopher, this question would never have been asked with the emphasis, nor pursued with the vigour, nor answered with the success which have attended it. It was the intellectual activity excited by the work which the civil engineers of England had accomplished that gave to philosophy the theory of the conservation of energy, including the dynamical theory of heat. Nor is the play of action and reaction between thought and practice likely to end here. For every gentleman in this great assembly, whose bent or vocation has led him to reflect on these things, well knows that the engineering genius of the future is certain to derive from this theory strength and guidance. Thus necessarily has thought originated fact, and fact originated thought. In the development of science these two powers are coequal; each in turn ceasing to be a consequence and becoming a creative cause. The Atlantic cable also had its small beginnings in the laboratory of the physical enquirer. Here, as before, experimental physics led the way to engineering feats of astounding magnitude and skill. But here also the positions of debtor and creditor have been reversed; for the work of the engineer has caused the physical inquirer to pursue his investigations with a thoroughness and vigour, and has given to those investigations a scope and magnitude which, without the practical stimulus, would have been impossible. The consequence is, that the practical realisation of sending electric messages along the bottom of the Atlantic has been an immense augmentation of our knowledge regarding electricity itself. Thus, Sir, does the human intelligence oscillate between sound theory and sound practice, gaining by every contact with each an accession of strength.

Mr. A. J. Beresford Hope, M.P.: I thank you very sincerely for having coupled Art and Engineering together, and I am exceedingly gratified to find that you have at length refuted a long-enduring error. What is civil engineering? It is the great manifestation to the world of power guided by science, and directed to the material good of man. Power is visible in its efforts—power is overwhelming in its results—but why should not power be linked with beauty and with grace? Those old Greeks—of whom we have all heard so much—knew this truth. In their own beautiful legendry there was a great engineering being, mighty in his inventions, mighty in his dealing with iron—the great god Vulcan. Vulcan was an accomplished engineer; but Vulcan was a rough fellow, and the gods in their wisdom gave Vulcan a wife—the goddess of beauty and grace and lightsomeness; and then Vulcan, great engineer as he was, became likewise a great artist, and erected, on the crest of Olympus, those gold and silver and diamond halls, which had any man ever seen them, which he never did, he would have pronounced were more beautiful than the greatest works of the greatest men of the earth. This old legend of Vulcan and Venus—and I say so in the face of him who controls the destinies of this land and the secrets of Homer—this legend was particularly set forth for the instruction of the Institution of Civil Engineers. I believe they have learnt their lesson. I believe they have had their flirtations now and then with Venus in the works they have carried out. I trace it in the Wolwyn and Balcombe viaducts, and that most graceful viaduct near to Brighton, which remain as monuments not only of engineering daring but of refined architectural conception, because these carry out the highest aim of architecture, namely, the plain, straightforward fulfilment of a practical end, displayed in forms that astonish the intellect by their appropriateness, and delight the taste by their nobleness of form. That combination, I say, which is the be-all and end-all of art, ought to be most conspicuously embodied in works of the greatest grandeur and the most solid material execution.

The Right Hon. H. A. Bruce: Upon me the task devolves of proposing for your appreciation the health of your respected President. In the honoured roll of those who have held that post there may have been—there probably were—men of equal eminence, but there have been none whose career has been more varied, more interesting, and more honourable. At a time when many gray-haired men now present were still unborn, our President was serving his country in the army of his sovereign. He took part in the hot attack and honourable repulse at Bergen-op-Zoom; he shared the triumphs under the Duke of Wellington at Vittoria; and in threading the passes of the Pyrenees with the British army, he first gained that experience which led him there again for more peaceful purposes. He watched by the cradle of engineering as applied to railways, and has himself been engaged in some of the most important works of this country; but it is in foreign countries that you must look for the chief consummation of his fame; and there is hardly a country, from Russia to the Northern and Southern States of America, in which he has not left some signal monument of his energy and ability.

The President: It was impossible for me to sit in my chair, as according to etiquette, I am aware, I ought to have done, while you so overwhelmed me with the toast you have drunk, and by the manner in which you have received it. I think my right honourable friend, whom I have the honour to meet for the first time to-day, and to whom I am gratefully sensible for the mode in which he has proposed my health, has paid a higher tribute to the character of the engineers of this country than to myself personally; for I am sure I have only done what any of you would have done if you had been placed in my position. If I have executed anything in Russia worthy of attention, I am bound to say I have been most nobly aided by my two sons, who are now following me. I say the same with regard to Brazil; but I would add, that anything I may have done there has been completely eclipsed by what has been dono by my friend, Mr. Brunlees. What I did was by pushing a way through a country in which it was possible to do something; but Mr. Brunlees has accomplished that which was at first deemed to be impossible. He has accomplished through a Brazilian forest that, in comparison with which my work was as nothing. Mr. Brunlees has carried out a most arduous, difficult, and, as I believe, remunerative work. To an extent, we may have been rivals to each other, inasmuch as we have carried railways through adjacent great provinces of Brazil. With respect to Russia, I was the first comer, and had the honour of receiving the confidence of the Emperor; and I did a great number of things at that time, having full confidence reposed in me.

We are given to understand that the late Mrs. Appold has left to the Institution a legacy of one thousand pounds, payable at the same time as the legacy for a similar amount from her husband, the late Mr. J. G. Appold, F.R.S., Assoc. Inst. C.E. It is believed that both bequests have been made "for the general use and benefit of the society," without being fettered with any conditions.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

CONTRIBUTIONS TO THE CHEMISTRY OF COPPER.

By T. Sterry Hunt, LD.D., F.R.S.

1. The resemblances between silver aud copper, iu its cupreous form, have already attracted the attention of chemists. The ordinary chloride of silver (argentic chloride) and the dichloride ot copper (cupreous chloride) have many properties in common. Both of these chlorides are white, readily fusible, and blackened by exposure to light. Both of them are insoluble in water, but dissolve in ammonia and in aqueous solutions of other chlorides, in which, however, the cupreous is far more soluble than the argentic chloride. A saturated solution of chloride of sodium holds, at 90° C., 16·9 per cent. of cupreous chloride; at 40° C., 11·7 per cent.; and, at 11° C., 8·9 per cent. A solution containing 15 per cent. of cbloride of sodium retains, at 90° C., 10·3 per cent. of cupreous chloride; at 40°, 6·0 per ceut.; and, at 14°, 3·6 per cent.; while a solution with only 5 per cent. of chloride of sodium holds, of the cupreous chloride, at 90°, 2·6, and, at 40°, only 1·1 per cent. These determinations are from single observations, and, therefore, require verification. From the sparing solubility of the cupreous chloride in dilute solutions of chloride of sodium, it follows that the denser saturated solutions are copiously precipitated by dilution with water, which causes the separatiou of white cupreous chloride iu a crystalline condition.

2. The aqueous solutions of the chlorides of calcium, magnesium, zinc, manganese, cobalt, ferrosum, and cuprosum also freely dissolve cupreous chloride; and it is probable that this property is shared by other soluble chlorides. The strong affinity of cuprosum for chlorine enables cupreous oxide to decompose all the chlorides just named, with the exception of those of sodium and calcium, with separation of the correspouding oxides and formatiou of cupreous chloride. In the case of zinc and manganese, insoluble oxychlorides of these metals are formed at the same time. These reactions require further study; and the same may be said of the cupric and cobaltic chlorides with cupreous oxide. I have, however, partially iuvestigated the behaviour of cupreous oxide with magnesic and ferrous chlorides, and obtained the results about to be described.

3. The cupreous oxide, for these experiments, was prepared by gently heating a solution of sulphate of copper, mixed with cane-sugar and an excess of caustic soda, until the whole of the copper was thrown down as a bright, dense cinnabar-red powder, which was carefully washed and dried. A concentrated solution of chloride of magnesium dissolves this oxide in tbe cold, and mor readily when heated, with separation of hydrated oxide of magnesium and cupreous chloride, which latter is held in solution by the excess of magnesic chloride. By filtering the liquid while hot, and washing with a strong solution of chloride of sodium, the hydrate of maguesia may be separated, and the dissolved copper subsequently precipitated by metallic iron from the colourless filtrate, ferrous chloride being formed. Experiment shows that the reaction between the red oxide of copper and cbloride of magnesium may be represented as follows:—

$$Cu_2O + MgCl = Cu_2Cl + MgO.$$

4. A solution of magnesian chloride, nearly saturated, when hot, with cupreous oxide, aud allowed to cool iu contact with the precipitated magnesian hydrate, deposits a portion of orange-coloured oxide, or perhaps an oxychloride, which disappears as often as the solution is heated. The solid cupreous chloride is, moreover, decomposed when digested with water and magnesia, hydrated cupreous oxide and magnesic chloride being formed. The double chloride of cuprosum and magnesium is, however, stable, even in the cold, in presence of magnesian hydrate, provided a considerable excess of magnesian chloride be present. From a filtered solution of cupreous oxide in chloride of magnesium, water precipitates a large portion of the cupreous chloride, in this case, coloured orange-yellow from adhering oxide, due to the reaction of a little magnesia which remains dissolved or suspended in the concentrated solution, even after filtration. A solution of magnesiau chloride of sp. gr. 1·23 retains in solution, at 12° C., about 7·10 per cent. of cupreous chloride. A solution of magnesian sulphate, with chloride of sodium, may be employed to dissolve cupreous oxide. This, like all similar solutions of cupreous chloride, rapidly absorbs oxygen from tbe air, and deposits a pale green cupric oxychloride.

5. With ferrous chloride and cupreous oxide, it might be expected, from analogy with the magnesian salt, that we should obtain cupreous chloride and ferrous oxide; but the reaction is complicated by the tendency of the latter to pass to the state of ferric oxide. When ferrous chloride in solution with chloride of sodium is heated with a sufficient quantity of cupreous oxide, the whole of the iron is precipitated as ferric oxide, mingled with metallic copper, while cupreous chloride remains in solution. Experimeuts made with an excess of ferrous chloride show that one-third of the copper is reduced, while two-thirds are dissolved as dichloride. This reduction may be effected directly by ferrous oxide. If, to a solution of cupreous chloride in cbloride of sodium, we add hydrated ferrous oxide recently precipitated by an alkaline base and still suspended in the liquid, it is at once converted into ferric oxide, with precipitation of metallic copper. The first stage in the action of ferrous chloride on cupreous oxide may be represented as similar to that of magnesic chloride,—

$$Cu_2O + FeCl = Cu_2Cl + FeO$$

in the second stage,

$$Cu_2Cl + 3FeO = Cu_2 + FeCl + Fe_2O_3.$$

It follows from this that one-third of the cupreous chloride formed in the first stage is reduced to the metallic state: and the final result may be represeuted as follows:—

$$3Cu_2O + 2FeCl = 2Cu_2Cl + 2Cu + Fe_2O_3.$$

A similar result is obtained if ferrous chloride is added to an unfiltered solution of cupreous oxide in chloride of magnesium. The suspended hydrate of magnesia, iu this case, liberates an equivalent of ferrous oxide, which reduces to the metallic state one-third of the dissolved cupreous chloride, iu accordance with the second reaction given above.

6. The reducing power of ferrous oxide is also showu with cupric chloride, which is at once converted by it into cupreous chloride, in accordance with the equation—

$$2CuCl + 3FeO = Cu_2Cl + FeCl + Fe_2O_3.$$

The further action of ferrous oxide will, as we have seen, reduce the cupreous chloride to the metallic state; in fact—

$$2CuCl + 6FeO = 2Cu + 2FeCl + 2Fe_2O_3.$$

If recently precipitated hydrated ferrous oxide or ferrous carbonate be added to a solution of cupric chloride in the proportions indicated by the last equation, the whole of the copper is separated in the metallic state, mingled with ferric oxide; while ferrous chloride is found iu solution. The reaction with ferrous carbonate, which requires a gentle heat, is accompanied by a violent disengagement of carbonic acid gas. This experiment is best made by dissolving in water ferrous sulphate and sodic carbonate, or sodic hydrate, in the proportions required, and adding thereto a solution holding the proper amount of cupric chloride. Under certain conditions, the cupreous precipitate is brownish black in colour, like that obtaiued by heating ferrous chloride with cupreous oxide; but more generally it is of a bright red colour, and often coats the glass with a mirror-like film. A warm solution of cupric chloride with chloride of sodium at once converts the metallic copper of the precipitate into cupreous chloride, which is dissolved, leaving behind only hydrated ferric oxide. When a solution of ferrous chloride with cbloride of ammonium and excess of ammonia is added to a solution of a copper-salt, the precipitated films of metallic copper sometimes possess considerable brilliancy, and show a bluish translucency. It is to be remarked that, although the cupreous precipitate thus obtained is bright red in colour, that which is produced by boiling cupreous oxide with ferrous chloride is nearly black.

7. It was long since shown by Levol that hydrated ferric oxide will reduce cupric to cupreous oxide; and this, as we have already seeu, can separate from its combinations ferrous oxide, whose reducing power may be still further exerted upon the cupreous combination thus formed. These facts serve to explain the results obtained by E. Braun (*Zeitschr. Chem.* 1867, p. 568; cited in *Jahresberichte* for 1867), which were not known to me at the time of making these experiments. He found that, by digesting cupric hydrate or cupric carbonate with ferrous sulphate in solution, there was obtained a reddish mixture of basic ferric sulphate with cupreous oxide, formed, apparently, iu accordance with the equation—

$$2FeO,SO_3 + 2CuO = Cu_2O + Fe_2O_3,2SO_3.$$

This, when boiled with a further portion of ferrous sulphate, became black in colour, and, from the small amouut of oxygen present, was supposed to coutain metallic copper. By adding a large excess of carbonate of ammonia to a mixture of ferrous and cupric sulphates, Brauu succeeded in obtaining solutions in which all the copper was present in a cupreous form, and even in reducing portions of it to the metallic state—a process which we have secu is complete when the requisite amount of ferrous oxide is brought in contact with the chlorides of copper.

1. In *Siliman's Journal* for March, 1867, p. 308, I described briefly the reaction between cupric oxide and ferrous chloride according to the equation—

$$3CuO + 2FeCl = Fe_2O_3 + Cu_2Cl + CuCl.$$

I was not then aware that the same had been shown by Meyer (*Berg. und Hutt. Zeit.* p. 182; cited by Kerl)* Further studies of this reaction have given me interesting results. The black oxide of copper, even after ignition, is attacked by ferrous chloride in the cold; but the insolubility of the resulting cupreous chloride retards the action. If, however, the ferrous chloride be mingled with a strong solution of chloride of sodium, and heat applied, the cupreous chloride is readily dissolved, and the reaction is rapid and complete, the whole of the iron separating as a bulky, reddish brown precipitate, provided three equivalents of cupric oxide have been taken for two of ferrous chloride. The greenish solution thus obtained readily dissolves precipitated metallic copper, in virtue of the

* "Metall. Huttenkunde," vol. xi., p. 588.

cupric chloride which it contains, and, unless a large excess of chloride of sodium be present, deposits white crystalline cupreous chloride by cooling or by dilution. When digested, at a temperature of 50° C., with carbonate of lime, the greenish solution deposits one-third of its copper as a pale green, insoluble, cupric hydrocarbonate, while the colourless filtrate retains the remaining two-thirds in the form of cupreous chloride. If a solution of ferrous chloride with chloride of sodium is digested with a sufficient excess of cupric oxide, the cupric chloride formed unites with the latter to form an insoluble cupric oxychloride, and only cupreous chloride remains in solution.

9. For the ferrous chloride in the experiments in Nos. 5 and 8, a solution of ferrous sulphate with chloride of sodium may be substituted. When cupric oxide is heated ferric oxychloride is produced. The red-brown precipitate may be washed free from cupric, cupreous, and ferrous chlorides by a strong solution of chloride of sodium, but will then yield to pure water a portion of soluble ferric oxychloride. By careful desiccation in a water bath, and subsequent washing with dilute alcohol, the ferric precipitate may be obtained free from chloride of sodium, and completely insoluble in water; but its composition appears to be variable. Of two preparations, the first contained 1 equivalent of chlorine for 11, and the second 1 for 20 equivalents of iron. In another experiment, where fine oxide of copper from the calcination of malachite was dissolved in an excess of a mixture of ferrous sulphate and chloride of sodium at a boiling heat, it was found that, for 30 equivalents of copper dissolved, there were precipitated 21 equivalents of iron, instead of 20, as required by the formula given in No. 8; the additional equivalent being separated as ferric chloride in union with the ferric oxide. The production of a small and variable amount of ferric chloride in the above conditions is apparently due to a secondary reaction between cupric and ferrous chlorides in the presence of ferric oxide,—

$$2CuCl + 2FeCl = Cu_2Cl + Fe_2Cl_3.$$

10. The facility with which cupric chloride parts with one-half of its chlorine, and passes into the more stable cupreous compound, is shown by its well-known power to chloridise, not only metallic copper, but metallic silver, and even sulphide of silver. Its action on cupreous sulphide is not less remarkable. A strong solution of cupric chloride, mingled with chloride of sodium, rapidly attacks pulverised copper-glance, even in the cold, sulphur being separated and cupreous chloride formed—

$$2CuCl + Cu_2S = 2Cu_2Cl + S.$$

Chalcopyrite, on the contrary, is but slightly acted upon by such a solution, which, however, slowly takes up a portion of iron, forming ferrous chloride with a corresponding amount of cupreous chloride.

IMPROVED DIAMOND-POINTED STEEL DRILL.

The following description of M. Leschot's invention is condensed from the *Scientific American*:—

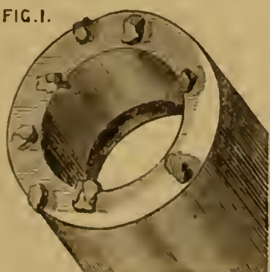
We have on various occasions called the attention of our readers to the great efficiency of opaque diamonds when applied to the cutting of hard materials. No existing substance can resist their action, and their durability when thus employed is very remarkable.

An annular drill used on the machine, which forms the subject of the present article, was recently employed in a tunnel of the Consolidated Bullion and Incas Silver Mining Company, Colorado, the tunnel having been at the time driven 600ft. into the mountain. This drill cut horizontally through 417½ft. of very hard quartz and feldspar rock; the expense for diamonds in drilling this distance being only thirty dollars.

This is only one of the daily accumulating proofs of the wond rful industrial value of the opaque diamonds, or—as they are more commonly called—carbons, and the great economy secured in their use for cutting and abrading the hardest materials.

From the study of the imperfections of the system of percussion drilling, M. Leschot conceived the idea of setting diamonds in an annular cutter, the general form of which is shown in Fig. 1.

FIG. I.



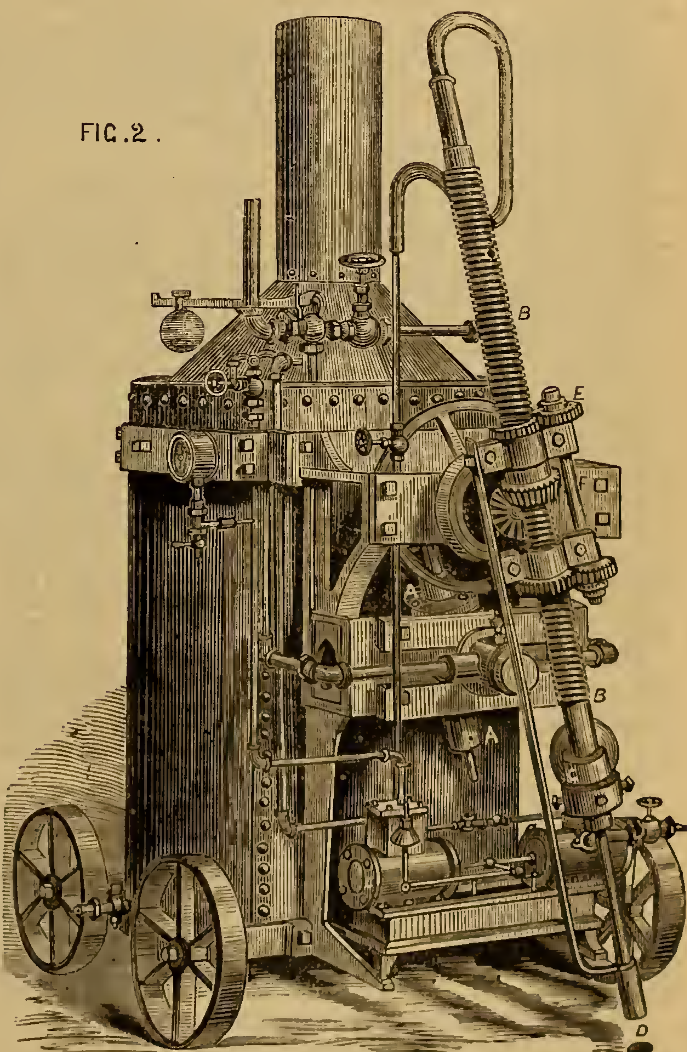
In the report of the Paris Exposition, the commissioners make a comparison between the power required to penetrate rock by means of this annular cutter, and that required by those drills which pulverise the rock to the full width of the hole, and pronounce the same to be in the proportion of 61 to 204.

This fundamental part of the device has, however, been improved upon since the introduction of the machine into this country. The diamonds are now securely fastened, and are set so as to give ample clearance, for the free descent of the drill, and the movement of the core through the tubular stem of the ring-cutter.

Great improvement has also been made in the various working parts of the apparatus. The original French machine only admitted the rotation of the drill at a speed of one-fourth that now employed. The feed gear has also been greatly improved, so that the cut of the diamond tool may be, without delay, changed from the one-hundredth part of an inch to the four-hundredth part of an inch at each revolution of the drill; and this gear is now so constructed as to automatically adjust the feed to varying hardness of the rock through which the drill successively penetrates, giving slower feed when hard *strata* are encountered, and resuming its rapid feed when the hard *stratum* is penetrated.

The oscillating cylinder engine has been substituted for the fixed cylinder engines, and is specially constructed to adapt it to this purpose; securing superior speed, lightness, steadiness, and durability.

FIG. 2.



A swivel head has also been added, by which the drill may be pointed in any direction; and the drilling may proceed at any possible angle with the vertical axis of the entire apparatus.

The hollow screw shaft is also an American improvement, which, added to the numerous other minor improvements, renders the machine, as we herewith present it, in the accompanying engravings, almost unrecognizable as the offspring of the original French machine.

The machines used in driving tunnels bore from three to five holes simultaneously, each in a different direction if desired.

Fig. 2 represents a "No. 1 Prospecting Drill," so called because of its general use in testing the character and value of mines and quarries. It consists of a small, upright boiler, to one side of which is firmly bolted the cast-iron frame which supports the engine and swivel drill-head, gear, and screw-shaft, as shown in the engraving. The engine—an oscillator of from five to seven h.p.—is shown at A. B is the screw-shaft with drill passing through it. This shaft is made of wrought iron pipe from 5ft. to 7ft. in length, with a coarse thread cut on the outside. This thread runs the entire length of the shaft, which also carries a spline by which it is feathered to its upper sleeve-gear. This gear is double, and connects by its lower teeth with the beveled driving-gear, and by its upper teeth with the release-gear, E. This release-gear is feathered to the feed shaft, F, at the bottom of which is a frictional gear fitting the lower gear on the screw shaft, which has one or more teeth less than the frictional gear, whereby a differential feed is produced. This frictional gear is attached to the bottom of the feed shaft, F, by a friction nut; thus producing a combined differential and frictional feed which renders the drill perfectly sensitive to the character of the rock through which it is passing, and maintains a uniform pressure upon the same. The severe and sudden strain upon the cutting points, incidental to drilling through soft into hard rock, with a positive feed, is thus avoided.

The drill proper (passing through the screw shaft, B), consists of a tubular boring bar, made of lap-welded pipe, with a steel bit or boring-head, D, screwed on to one end. This bit is a steel thimble about 4in. in length, having three rows of black diamonds in their natural rough state firmly bedded therein, so that the edges of those in one row project forward from its face, while the edges of those in the other two rows project from the outer and inner peripheries respectively.

The diamonds of the first-mentioned row cut the path of the drill in its forward progress, while those upon the outer and inner periphery of the tool enlarge the cavity around the same, and admit the free ingress and egress of the water as hereafter described. As the drill passes into the rock, cutting an annular channel, that portion of stone encircled by this channel is of course undisturbed, and passes up into the drill in the form of a solid cylinder. This core is drawn out with the drill in sections of from 8ft. to 10ft. in length.

The sides of the hollow bit are one-fourth of an inch thick, and the diamonds of the inner row project about one-eighth of an inch, so that the core or cylinder produced by a 2-inch drill (the ordinary size for testing) is 1¼in. in diameter.

Inside the bit D is placed a self-adjusting wedge, which allows the core to pass up into the drill without hindrance, but which impinges upon and holds it fast when the action of the drill is reversed—thus breaking it off at the bottom, and bringing it to the surface when the drill is withdrawn.

In order to withdraw the drill it is only necessary to throw out the release gear E, by sliding it up the feed-shaft F, to which it is feathered, when the drill runs up with the same motion of the engine which carried it down, but with a velocity sixty times greater—that is, the speed with which the drill leaves the rock, bringing the core with it, is to the speed with which it penetrates it as 60 to 1—the revolving velocity in both cases being the same.

The drill rod may be extended to any desirable length by simply adding fresh pieces of pipe. Common gas pipe is found to serve admirably for this purpose, the successive lengths being quickly coupled together by an inside coupling four inches long, with a hole through the centre of each to admit the water. The drill is held firmly in its place by the chuck G at bottom of the screw shaft.

The small steam pump C C is connected by rubber hose with any convenient stream or reservoir of water, and also with the outer end of the drill pipe, by a similar hose having a swivel joint, as shown in the engraving. Through this hose a ½-inch stream of water is forced by the pump into the drill from which it escapes between the diamond teeth at the bottom of the bit D, and passes rapidly out of the hole at the surface of the rock carrying away all the grit and borings as fast as produced. Where water is scarce or difficult of access, a spout is laid from the mouth of the hole to the tank or reservoir and a strainer attached to the connecting hose, so that the same water may be used over and over again with but little loss.

This pattern rotates the drill from 300 to 600 revolutions per minute.

A machine like that shown in fig. 2, cut through Hell Gate Rock (very hard) at the rate of 8½in. in 4½ minutes, and through brown sandstone at the rate of 13in. in 2¼ minutes in our presence, notwithstanding that its operation was retarded by the bad quality of the oil used for its lubrication, and want of sufficient steam to run at maximum speed.

In very hard trap-rock, quartz, or granite, 8ft. per hour is found to be fair average rate of boring, where holes are not required to be over 100ft. deep and 2in. in diameter; while in sandstone, marble, slate, &c., 15ft. per hour is easily bored.

DURING the process of paying out, the signals through the Falmouth, Gibraltar, and Malta Telegraph suddenly ceased on the 20th ult.

ON THE MERCANTILE AND ADMIRALTY RULES FOR CALCULATING THE POWER OF MARINE STEAM ENGINES.

By ROBERT ARMSTRONG.

(*Concluded from page* 109).

I think the comparison of these co-efficients with the corresponding velocities of the piston, point very decidedly to the direction in which the investigation should proceed.

For this purpose, as I have already premised, that the science of mathematics is sufficient with such data, to solve this problem, I retain the theoretical principles of the formula,

$$C = \frac{\text{Mid Sec.} \times V^3}{\text{I H P}}$$

or, transposed,

$$C \times \text{I H P} = \text{Mid Section} \times V^3$$

Now if the conventional term of Indicated H.P. is abandoned, and the actual quantities introduced, the terms of the equation will be thus expressed:—

$$C \times \text{Pressure} \times \text{Vel. of Piston} = \text{Mid. Sec.} \times V^3$$

Now as the velocity of the piston is the subject under discussion, and the value of which we want to obtain; let it be made the unknown quantity (x). Therefore, to bring out its value in foot pounds, it is necessary to reduce the velocity of the vessel from knots to feet per second; and as we are leaving out the velocity of the piston on one side, we must reduce the power of the velocity of the vessel on the other side of the equation to the square of the speed; it being an established axiom in fluid resistance, that the tractive force varies as the square of the velocity. The equation will now stand thus—

$$C \times x \times \text{Pressure} = \text{Mid. Sec.} \times V^3$$

$$\text{or, } C\,x = \frac{\text{Mid. Sec.} \times V^2}{\text{Pressure in Cylinders}}$$

The theory of this method of analysis completely negatives the value of the velocity of the piston. Therefore, if it has the value ascribed to it by the Admiralty rule, the engines with *the highest velocity of piston ought to show the highest co-efficient*, or what I may term, the actual amount of mechanical effect (foot lbs.) developed by each pound pressure in the cylinders of the engine. If this theory of investigation is correct, it only remains to test the principle by the trials of the same vessel—the same description of propeller—and sufficient variation in the velocity of piston, so that the question of form or propeller cannot disturb the calculation. For this purpose I have selected the trials of the *Flying Fish*, as they present sufficient variation in the velocity of the piston to test its value by means of the formula (the data published by the Admiralty, in 1859).

"FLYING FISH" EXPERIMENTS.

	Velocity of vessel, feet per second.	Mid Section.	Mid Sec. × V^2 feet per second.	Pressure in cylinders, lbs.	Value of the Speed of Piston, foot lbs.	Velocity of Piston, feet per second.	$C = \frac{\text{Mid. Sec.} \times V^2}{\text{I. H. P.}}$	Indicated H. P.
Experiment 4 ...	16·76	277	77837	68791	1·12	4·61	469	576
Do. 5 ...	18·92	277	99792	94305	1·04	5·12	443	877
Do. 6 ...	19·26	277	102767	103512	·98	5·40	411	1016
Do. 3 ...	19·77	272	106352	114188	·96	5·62	376	1166
Do. 7 ...	19·60	277	106368	114400	·96	5·58	372	1160
Do. 2 ...	19·09	274	100010	106576	·94	5·96	341	1154
Do. 1 ...	19·43	281	106218	116466	·94	6·15	335	1302

Now if we examine the fifth column, under the heading of the value of the speed of piston, or what may be termed the co-efficient of my formula, we shall find that the trial with the least velocity of piston, 4·61ft. per second, has produced the largest amount of mechanical effect, 1·12 foot-pounds, while the first experiments with the highest velocity of piston, 6·15ft. per second, exhibits the smallest co-efficient, or ·94 foot-pounds, thus proving that the increased speed of piston has not the value ascribed to it by the Admiralty rule; on a further perusal we shall find that the speed of the vessel is more proportionate to the pressure in the cylinders than to the indicated H. P. For example, it will be seen that in the seventh trial 1,160 I. H. P. has produced the same speed of vessel as 1,302 I. H. P. in the first experiment, while the pressure in the cylinders is on an equality.

In this vessel the fact is again disclosed, that the Admiralty co-efficients vary exactly as the velocity of the piston, and in the same manner as in the previous trials submitted for perusal; while the co-efficients by my formula, which leaves out the velocity of the piston, remains *nearly constant*, which it is only reasonable to suppose, ought to be the fact, when the same vessel, engine, and propeller is employed.

I regret the paucity of trials of vessels of similar character, having a velocity of piston approximating to the mercantile rule for making an extreme comparison with the Admiralty practice. The nearest selection I can find in the form of vessel is the *Miranda* (a geared engine 3 to 1), and the fifth trial of the *Flying Fish*, the *Victor*, and *Pioneer* (of direct action), the speeds of these vessels being nearly equal, for further testing these two rules.

On the perusal of the annexed data it will be found that the *Miranda* is the slowest vessel, but then she has the largest immersed midship section and displacement, which places her on an equality with the other vessels.

Now, if the velocities of these vessels for a comparison are equal, surely it is only reasonable to suppose that the propelling power would be on the same equality. Let the data decide.

I have examined every trial published at the Admiralty, and have failed to discover a single fact in its favour; and if I may venture a suggestion to its advocates, the best argument will be to assert that the Admiralty data is merely a fortuitous concourse of figures in favour of the mercantile rule.

Thus far, I have shielded my own opinions under the cloak of establishing the truth of the mercantile rule; but my perusal of these trials leads me to believe that this mass of valuable data will be the means of adding a most important numerical constant to the first law of thermodynamics, viz, that heat, motive power, and mechanical effect are mutually convertible, &c.

Now, a pressure of steam is one of the effects of heat. A pound of coal can only evaporate a certain quantity of water, a cubic foot of water will only produce a given volume of steam, the action of gravity is constant, matter is indestructible, and every substance in nature has its equivalent. The mechanical equivalent of heat has been determined by Professor Joule at 772 foot lbs. By this method of reasoning, my own opinion is that the mechanical effect (work) of a pressure of steam is a constant quantity; consequently the problem I suggest for the solution of this and all other mechanical principles is, What is the mechanical equivalent of force, or a pressure of steam? My investigations on this subject incline me to assert that a pressure of about 550lbs. is the force required to produce 33,000 foot lbs. in one minute; or, in other terms, that 1lb. pressure will produce 1ft. lb. in one second of time.

Name of Vessel.	Velocity feet per second,	Mid Section.	Mid. Sec. × V² feet per second.	Pressure in Cylinders, lbs.	Value of the Speed of Piston, foot lbs.	Velocity of Piston, feet per second.	C = Mid. S. × V³ / I. H. P.	Indicated H. P.	Nominal H. P.	Collective area of Cylinders.	Length of Stroke. ft. in.
Miranda	18·08	336	109372	94720	1·14	3·56	680	613	250	4992	3 9
Pioneer	19·09	277	99645	95988	1·02	6·83	336	1192	350	4750	2 6
Flying Fish	18·92	273	99166	94305	1·04	5·12	443	877	350	5284	2 3
Victor	19·43	264	99792	93886	1·06	6·83	351	1165	350	4750	2 6
Algiers	15·21	1053	243243	211116	1·14	2·91	687	1117	450	11688	3 3
Rattler	17·02	274	79460	67904	1·16	3·46	654	428	200	5024	4 0
Desperate	14·99	388	87300	85200	1·02	2·51	697	389	400	9500	2 6
Hercules	24·82	1315	810040	437371	1·85	10·72	489	8528	1200	21870	4 6
Achilles	24·20	1309	765902	432300	1·77	7·28	671	5722	1250	17071	4 0

It will there be observed that what is called indicated horse-power varies nearly 100 per cent., or 613 and 1,192 I.H.P., while the pressure on the cylinders only varies less than 2 per cent., or 94,720lbs. to 95,988lbs. It will thus be seen that the same amount of pressure with only one-half the velocity of piston, or 3·56ft. to 6·83ft. per second, has produced the same quantity of mechanical effect—the speed of the vessel. It is needless to observe that the Admiralty coefficients are again in proportion to the velocity of the piston, or 680 to 336; while the co-efficients by my formula are respectively 1·14 and 1·02.

With such facts, the question naturally arises, how much further can the velocity of the piston be reduced without diminishing the efficiency of the pressure on the cylinders of the engine?

We have had the fact recorded that the *Algiers*, with a speed of 9 knots, had only a velocity of piston of 176ft. per minute; the *Rattler*, the first screw vessel in H.M.'s Navy, reached a speed of 10 knots, with a speed of piston of 208ft. per minute; while the *Desperate*, with nearly a speed of 9 knots, the velocity of the piston was only 150ft. per minute. I may here observe that the Admiralty co-efficients of these vessels have scarcely or ever been exceeded by any of the more modern vessels, being respectively 687, 654, and 697, and by my formula, 1·14, 1·16, and 1·02.

As economy in our naval administration is the order of the day, one more comparison will exhibit the utter fallacy of the Admiralty rule. The vessels are the *Achilles*, and the last addition to our ironclad fleet, the *Hercules*. At the trials at the measured mile—the velocity, the immersed midship section, and displacement were nearly equal for a comparison, being 14·332 and 14·691 knots; while the I.H.P. developed by the engines of the *Hercules* was 8,528, or nearly 3,000 I.H.P. in excess of what propelled the *Achilles*; and here, again, the same fact presents itself—*the pressure in the cylinders was on an equality*. And for this equality of speed of vessels, the velocity of piston in the *Hercules* was 10·72ft. per second, or nearly one-half the velocity of the ship herself; while that of the *Achilles* was only 7·28ft. per second, or a difference of 206ft. per minute, the data being as follows:—

	Achilles.	*Hercules.*
Speed of vessel	14·332	14·691 knots.
Midship Section	1,307	1,315
Displacement	9,487	8,680 tons
Indicated horse-power	5,722	8,528
Pressure	432,300	437,371 lbs.
Velocity of piston	436	643 per min.
Admiralty co-efficient	671	489
C x	1·77	1·85

ANNUAL INTERNATIONAL EXHIBITIONS.

Her Majesty's Commissioners for the Exhibition of 1851 have issued an announcement of their intention to hold a series of annual International Exhibitions of selected works of fine and industrial art and scientific inventions. The first Exhibition of the series will be opened at South Kensington (in a permanent building to be erected for the purpose) on the 1st of May, 1871, and will be closed on the 30th of the following September.

The first Exhibition will consist of the following classes, for each of which a reporter and a separate committee will be appointed:—

Division I.—Fine Arts.

FINE ARTS APPLIED OR NOT APPLIED TO WORKS OF UTILITY.

"Class 1.—Painting of all kinds in oil, water colours, distemper, wax, enamel, and on glass, porcelain, mosaics, &c. Class 2.—Sculpture, modelling, carving, and chasing in marble, stone, wood terra-cotta, metal, ivory, glass, precious stones, and any other materials. Class 3.—Engraving, lithography, photography, &c. Class 4.—Architectural designs, drawings, and models. Class 5.—Tapestries, carpets, embroideries, shawls, lace, &c., shown not as manufactures, but for the fine art of their design in form or colour. Class 6.—Designs for all kinds of decorative manufactures. Class 7.—Copies of ancient or mediæval pictures, mosaics, enamels, reproductions in plaster, fictile ivory, electrotypes of ancient works of art, &c.

Division II.—Manufactures.

MANUFACTURES, MACHINERY, AND RAW MATERIALS.

"Class 8—Pottery of all kinds—viz., earthenware, stoneware, porcelain, Parian, &c., including terra-cottas used in building, with any new raw materials, new machinery, and processes for the preparation of such manufactures. Class 9.—Woollen and worsted fabrics, with any raw produce from new sources or prepared by any new process, and new machinery for woollen and worsted manufactures. Class 10.—Educational works and appliances. Section A.—School buildings, fittings, furniture, &c. Section B.—Books, maps, globes, instruments, &c. Section C.—Appliances for physical training, including toys and games. Section D.—Specimens and illustrations of modes of teaching Fine Art, natural history, and physical science. Section E.—Specimens of school work, serving as examples of the results of teaching.

Division III.—Scientific Inventions and new Discoveries of all kinds.

"Detailed rules and lists of the separate trades engaged in the production of objects of manufacture will be issued.

Division IV.—Horticulture.

"International Exhibitions of new and rare plants, and of fruits, vegetables, flowers, and plants, showing specialities of cultivation, will be held by the Royal Horticultural Society in conjunction with the above Exhibitions. Special rules for Horticultural Exhibitions will be issued by the Royal Horticultural Society."

Among other general rules it is announced that the arrangement of the objects will be according to classes, and not, as in former International Exhibitions, according to nationalities.

One-third portion of the space in each class will be assigned to such foreign exhibitors as shall obtain certificates for the admission of their objects from their respective Governments. Foreign countries will appoint their own judges. The remaining two-thirds of the space will be filled with objects produced either in the United Kingdom or abroad, and sent direct to the building for the inspection and approval of judges appointed for the purpose. Her Majesty's Commissioners will provide large glass cases, stands, and fittings, steam and water power, and general shafting, free of cost to the exhibitors; and, except in the case of machinery, will carry out the arrangement of the objects by their own officers. Prices may be attached to objects, and each object must be accompanied by a descriptive label stating the special reasons, such as excellence, novelty, or cheapness, for which it is offered for exhibition. Reports of each class of objects will be prepared immediately after the opening, and will be published before the 1st of June; while foreign countries will be permitted to accredit a reporter for every class in which they exhibit, for the purpose of joining in the reports. No prizes will be awarded, but a certificate of having gained the distinction of admission to the Exhibition will be given to each exhibitor.

A catalogue of the various works displayed will be published in the English language, and will contain not only brief descriptions of the works themselves, but also, in many cases, some notice of the exhibitor—such as his birth-place, his place of residence, the masters under whom he may have studied, and the distinctions that he has gained. Every foreign country will be at liberty to publish a catalogue in its own language, if it should see fit to do so.

Her Majesty's Commissioners desire to call special attention to the first division of the projected Exhibition. They point out that hitherto the exhibition of works of Fine Art has been too much limited to the display of pictures and sculpture dissociated from purposes of utility, and that it is doubtful whether a picture on enamel or pottery, however great its merits, if destined to be applied to a piece of furniture, would find a place in any of the Exhibitions of the Royal Academy of London. In the undertaking under their control, the Commissioners purpose to remedy this defect, and to furnish an opportunity of stimulating the revival, from ancient and mediæval periods, of the application of the artist's talents to give beauty and refinement to every description of object of utility whether domestic or monumental. Painting, on whatever surface, or in any method, sculpture in every description of material, engravings of all kinds, architectural design as a Fine Art, every description of textile fabric of which Fine Art is a characteristic feature—in short, every work, whether of utility or pleasure, which is entitled to be considered a work of excellence from the artistic point of view, may be displayed in the Exhibition under the division of Fine Art. Every artist workman, moreover, will be able to exhibit a work of merit as his own production, and every manufacturer may distinguish himself as a patron of art by his alliance with the artistic talent of the country. In the Fine Art section the artist may exhibit a vase for its beauty of painting or form, or artistic invention, while a similar vase may appear in its appropriate place among manufactures on account of its cheapness or the novelty of its material.

The month of February in 1871 will be devoted to the reception of objects for exhibition, and days have been assigned to the various classes. It is announced that no object will be received at any other time than on one of the days set apart for the class to which it belongs.

Obituary.

MR. ZERAH COLBURN.

We regret to announce the death of this distinguished writer upon engineering subjects, which took place on the 27th of April, at Belmont, near Boston, U.S. Mr. Colburn, who was an entirely self-made man, was born in the year 1832, at Saratoga, and first made his appearance as an author when only about 15 years of age. In about the year 1858, he settled in England, and was employed as editor of the *Engineer*, but in consequence of some misunderstanding between him and the proprietors of that paper, he relinquished that post in the year 1864, and about a year afterwards started a paper for himself—*Engineering*—which he continued to edit until within the last few months. As a writer he was always vigorous and lucid, sometimes perhaps too vigorous, while for rapidity of composition he was almost unrivalled.

NOTES AND NOVELTIES.

MISCELLANEOUS.

Asphalte Pavement.—The Commissioners of Sewers for the City of London are showing a worthy desire to solve the pavement problem, especially as to the value of asphalte. More than two years since an admirable piece of granite pavement fixed by asphalt, instead of by lime and sand, was laid in Duke-street, Smithfield, and the experience gained there seems to prove it to be the best adapted to sustain the heavy and severe traffic of the London streets. For two years it sustained the Holborn traffic, which now passes over the Viaduct, and not a single stone has shown the slightest appearance of wear or displacement. A further portion is now laid down inside Temple-bar. The merits of asphalt pavement are that it gives clean streets in winter by preventing the pumping up of mud from between the stones which the old system favours and, also prevents dust in summer by stopping up the source whence the dust comes. The sewers will also be relieved of an immense amount of solid *detritus* coming from this source. Asphalte being impervious to water, the bed will always keep dry and intact. Credit is due to Mr. Pedler for having brought it into use in London.

Freights from Bombay.—According to advices received in Liverpool from Bombay, the large number of steamers which are trading between the different ports of Europe and Bombay by the Suez Canal has caused a complete revolution in the freight market in Bombay. On the 16th of April freights were reported to have been—for sailing ships, from 20s. to 22s. 6d.; and for steam vessels, by Canal, from £2 to £2 7s. 6d.

Naples Maritime Exhibition.—A communication has been received by the British Commissioners of the International Maritime Exhibition, which is to be held at Naples from the 1st of September to the 30th of November in the present year, stating that a transport will be despatched to England in June, for the purpose of conveying to Naples free of all charge, the objects selected in England for the display.

LAUNCHES

On the 18th ult Messrs. Caird and Co. launched from their building-yard a handsome screw steamer of 2,690 tons which was gracefully named *Thuringia* by Miss Benson, Philadelphia. The dimensions of the steamer are as follows:—Length of keel to fore-rake 340ft. breadth of beam 40ft. and depth of hold to main deck 26ft. She will be propelled by engines of 600 horse-power. The *Thuringia* is a sister ship to the *Selesia*, and is owned by the Hamburg-American Steam Packet Company. She is intended for the Bremen and New York trade. The new steamer will be commanded by Captain Ehlers.

On the 19th ult there was launched from the shipbuilding yard of Mr. John Elder, Govan, the *Loanda*, an iron screw steamship of 1,326 tons B.M. and 250 H.P. nominal, and of the following dimensions:—Length between perpendiculars, 278ft.; breadth, 31ft.; depth of hold to main deck, 23ft. 2in. The *Loanda* has been built to the order of the British and African Steam Navigation Company of Glasgow, and is intended for their trade on the West Coast of Africa. The builder has two sister ships—viz., the *Liberia* and the *Volta*—on the stocks for the same owners.

There was launched from the shipbuilding yard of Messrs. John Reid and Co., on the 17th ult, a first-class iron barque of 900 tons register, named the *Oceola*, for Messrs. Alex. Ramage and Co., Liverpool.

Messrs W. Denny and Brothers, have contracted to build for the British India Steam Navigation Co., two screw steamships about 1,900 tons each. They have previously supplied twelve steamers to the same company.

The London and Glasgow Engineering and Iron Shipbuilding Company launched on the 3rd ult., from their yard at Govan a beautiful iron screw steamer of about 650 tons, for H. L. Seligmann, Esq., of Glasgow. She is to be fitted by the builders with engines of the most improved construction for economising fuel, and will have splendid passenger accommodation. We understand she is intended for the Gothenburg trade.

Messrs. Barclay, Curle and Co., launched for the Messrs. Kelso, Union Street, the *Nola*, a handsome iron barque of 500 tons register, built to the highest class at Lloyd's, and which, we believe, the owners intend employing in the East India trade.

On the 18th ult., there was launched from the shipbuilding yard of Messrs. M'Culloch, Patterson and Co., Port-Glasgow, a handsome iron barque, of 700 tons register. She was named *Firth of Clyde*, by Mrs Alex. Brown, Greenock. She is owned by Messrs. A. and J. Brown, of that port, and is chartered by Messrs. Aitken, Lillbum and Co., Glasgow, for New Zealand.

On the 16th ult., Messrs. Henderson, Coulborn and Co., launched from their building-yard at Renfrew a twin screw-steamer of 400 tons for the West African Company (Limited). She is fitted with two separate engines, on the builders' compound principle, of the collective power of 90 horses nominal. As she glided off the ways she was named the *Victoria* by Mrs Stott, the wife of the captain who is to take the command.

On the 2nd ult., Messrs. Robert Duncan and Co. Port-Glasgow, launched from their building yard, Port-Glasgow, a handsome paddle-steamer for the Greenock and Helensburgh Steam-Packet Company, which was named *Craigrownie*, by Miss Brymner, Forsyth Street, Greenock, sister of one of the owners. The *Craigrownie* is 175ft. long and 17ft. breadth of beam. She will be propelled by engines supplied by Messrs. Rankin and Blackmore, Greenock, of 70 H.P.

Messrs. J. and R. Swan launched on the 10th ult., from their building-yard at Maryhill Glasgow a screw steamer, named *Onoba*. She has been built to the order of the Tharsis Sulphur and Copper Co. (Limited), Glasgow, for her owners, in Huelva, who intend her for general goods traffic and towing of barges on the Odiel river, and to and from neighbouring ports. She is being engined by Messrs. W. M. Robertson and Co., Clyde Street Engine Works, Glasgow. Messrs. Swan have at present in course of construction other two screw steamers, one being for the Glasgow and Ayr trade, and the other for foreign traffic.

On the 12th ult., an extra strongly-built iron steam-tender, of 170 tons register, and 40 horse-power, was launched from the yard of Messrs. R. Duncan and Co., Port-Glasgow for Messrs. Handyside and Henderson, Glasgow. The Anchor Line Company's fleet of steamers, with this addition, now numbers 33 vessels, engaged in the American and Mediterranean trade. This addition was found necessary for the purpose of conveying goods to and from the steamers while lying off Greenock, the great draught of the larger vessels rendering it desirable that they should be lightened for the river navigation.

ON the 23th April there was lanuched from the shipyard of Messrs. James and George Thomson, at Govan, a handsome iron screw steamer, for the West Highland line of Messrs. David Hutcheson and Co. The *Clansman* is 750 tons measurement. She will be elegantly fitted up for 50 first-class passengers, and will be supplied by the builders with compound surface-condensing engines of 150 horse-power. The *Clansman* is the fourteenth steamer built by Messrs. J. and G. Thomson for Messrs. D. Hutcheson and Co. Messrs. Thomson have on hand to order steam tonnage amounting to upwards of 13,500 tons.

TRIAL TRIPS.

ON the 29th April the London and Glasgow Engineering and Iron Shipbuilding Co. (Limited) invited a party of friends to accompany the new screw steamer *Caspian*, built by them for Messrs. J. and A. Allan, of Glasgow, on a preliminary trip previous to the vessel being handed over to her owners. The *Caspian* is a barque-rigged steamer of 2,560 tons, and is of the following dimensions, viz.:—Length over all, 360ft.; breadth, 38ft.; and depth of hold to weather deck, 32ft. Her engines, which are inverted surface condensing and fitted with patent gridiron valve motion, are of 400 horse-power, the diameter of cylinders being 67in. and stroke of piston 42in. Accommodation has been provided on board for 64 first-class, 42 second-class, and 500 steerage passengers, while the officers and crew have excellent berths allotted them. The main saloon, which is fitted with bird's-eye maple and gold mounting, can accommodate 70 persons at dinner. The ventilation and heating of the ship is very complete, while every scientific improvement for the comfort of the passengers and the stowage of cargo has been introduced.

THE S.S. *Glenjarnock* was officially tried on 27th April by a run from Ardrossan to Boodick Bay and back. This vessel is of handsome model, and is owned by Messrs. Merry and Cunninghame, and will be employed in the home iron trade. She was built by Messrs. John Fullerton and Co., Paisley, and was engined by Messrs. King and Co., Dock Engine Works, Glasgow. Her principal dimensions are 130ft. in length, 20ft. in breadth, and 10 deep in hold; carrying capacity, 300 tons; classification at Lloyds, A1. She is furnished with a pair of condensing engines of 45 H.P. nominal, having horizontal tubular boiler, and all the usual fittings, with steam winch on deck, and separate donkey boiler in stoke hole. The day's steaming showed a result of 10½ knots per hour, which was considered highly satisfactory.

THE official trial of the Cunard liner *Batavia* took place on the 29th April. She has been built, engined, and fitted by the Messrs. Denny, of Dumbarton, according to the instructions of her owners, and is in every respect a very fine specimen of naval architecture. She is 2,600 tons, her length being 327ft. and her breadth 39ft. 4in., while she has accommodation for 100 cabin and 1,000 steerage passengers. The engines are on the compound principle, of great strength and exquisite finish, and worked with remarkable smoothness. The maximum speed attained in running the measured mile was 13¾ knots per hour, with 1,000 tons dead weight of iron on board. The cabin saloon is very elegantly fitted the woodwork being all of satinwood and teak, and it is, of course, provided with every comfort and luxury requisite to make a voyage across t e Atlantic as enjoyable as a sea-voyage possibly can be.

RAILWAYS.

METROPOLITAN TRAMWAYS.—The second of the experimental routes of metropolitan tramways is now in active operation from Whitechapel Church to Bow Church. On the important points of time and fares this tramway shows some advantage, inasmuch as the distance is traversed in about twenty minutes, at a rate of twopeuce per passenger. Another point gained is that of additional room in the interior of the vehicle, where a passenger can enter and find a seat without annoyance and discomfort. Against these benefits the most important set-off to the general traveller is perhaps the rumbling of the wheels on the rail, the noise so created being considerably more pronounced than that caused by either railway train, or omnibus. As to interruption of general traffic, there is really no objection to the lines. The car on the rails occupies no more time in passing a given point than any other carriage, and can be pulled up in a shorter space and with less shock than anything else drawn by horses at the rate of seven miles an hour on an ordinary road. These cars were built in America, are 16ft. long, and by projecting over the wheels, are enabled to give more space than can be afforded by omnibuses of the ordinary gauge. Messrs. Fisher and Parrish, of Threadneedle-street, have constructed the line, under the direction of Mr. Hopkins, of Parliament-street, their engineer. It is proposed to extend the tramway to Stratford, and there is just now a bill in Parliament to enable the company to go on to Leytonstone, a distance of three miles eastward beyond the present limit. Each car will carry twenty-two passengers inside and twenty-four out. At present the novelty of the scheme has its attractions for the million, and there is both on the East line and that opened between Brixton and Kennington, quite a rush for places in every bus. On the first Sunday after it was opened no fewer than 4,000 passengers were carried after two p. m. on the South line, although the fare there is the rather high one of twopence for a mile and a quarter, and there is no reason to doubt that fully 2,000 more would have gone if there had been room for them.

DOCKS, HARBOURS BRIDGES,

According to a circular of Messrs. H. E. Moss and Co., the change that has ensued rom the arrival of steamers through the Suez Canal has been greater than was anticipated. Many of the steamers sent eastward are too small, but when all those now building are at work the traffic will be considerably augmented, and taking into consideration that a steamer can makethree round voyages in 12 months, either to and from Calcutta or Bombay, each steamer will displace three sailing-ships of equal tonnage. Much is yet required to improve the navigation of the Canal, but it appears there is a uniform depth of water in the centre of 24ft. and a steady development and increase of communication is anticipated from week to week. Although freights cannot be called very remunerative, there are few steamers unemployed. "Nearly everything is at work, all those steamers that were lying up unsold have passed from builders' hands, with one solitary exception, and those few built on speculation are either sold or in treaty before being finished."

THE intelligence sent to Government from the Darien Canal Surveying Expedition indicates that, although the surveys are not yet completed, the construction of a canal across that part of the isthmus is impracticable.

PROPOSED SHIP CANAL FROM MANCHESTER TO LIVERPOOL.—In consequence of the success of the Suez Canal, the proposal of a ship canal from Manchester to Liverpool has been revived. It is proposed to do with the River Irwell what Glasgow has done with the Clyde. Mr. Hamilton Fulton, C.E., has made a survey, and proposes, after cutting off the bends, to widen and deepen the bed of the river. It would be a tidal channel of 33 miles, of which 19 would be excavations and deepening, and 14 training; 200ft. wide at the surface and 80ft. at the bottom, with a *minimum* depth of 22ft. The cost of land, construction of wharves, roads, and railway bridges, and compensation for mills, &c., is estimated at £1,000,000 and the cost of deepening, widening, and dredging will not exceed £1,500,000. It is calculated that a trade of 3,000,000 tons inwards and outwards might be forthcoming, upon which 2s. per ton would give £300,000 or 8 per cent., after all expenses.

MINES, METALLURGY, &c.

THE report of the Geological Survey of British Burmah announces the discovery of petroleum near Thayetmycho.

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	s.	d.	To £	s.	d.
COPPER.						
Best selected, per ton	73	0	0	74	0	0
Tough cake and tile do.	71	0	0	72	0	0
Sheathing and sheets do.	75	0	0	,,	,,	,,
Bolts do.	76	0	0	,,	,,	,,
Bottoms do.	78	0	0	,,	,,	,,
Old (exchange) do.	63	0	0	,,	,,	,,
Burra Burra do.	73	0	0	74	0	0
Wire, per lb.	0	0	10	,,	,,	,,
Tubes do.	0	0	11	,,	,,	,,
BRASS.						
Sheets, per lb.	0	0	8¼	0	0	0
Wire do.	0	0	7¼	,,	,,	,,
Tubes do.	0	0	10	,,	,,	11½
Yellow metal sheath do.	0	0	6½	0	0	6¾
Sheets do.	0	0	6¼	,,	,,	,,
SPELTER.						
Foreign on the spot, per ton	19	5	0	19	10	0
Do. to arrive	19	5	0	19	10	0
ZINC.						
In sheets, per ton	23	10	0	,,	,,	,,
TIN.						
English blocks, per ton	136	0	0	137	0	0
Do. bars (in barrels) do.	137	0	0	138	0	0
Do. refined do.	141	0	0	,,	,,	,,
Banca do.	133	0	0	134	0	0
Straits do.	132	0	0	133	0	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	6	6	1	8	0
IX. do. 1st quality do.	1	12	6	1	13	6
IC. do. 2nd quality do.	1	6	0	1	6	6
IX. do. 2nd quality do.	1	12	0	1	12	6
IC. Coke do.	1	3	0	1	3	6
IX. do. do	1	9	0	1	9	6
Canada plates, per ton	13	10	0	14	10	0
Do. at works do.	13	0	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	5	0	,,	,,	,,
Do. to arrive do.	7	5	0	,,	,,	,,
Nail rods do.	7	5	0	7	10	0
Stafford in London do.	8	5	0	9	0	0
Bars do. do.	8	0	0	9	0	0
Hoops do. do.	8	15	0	9	0	0
Sheets, single, do.	9	15	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	0
Bars, common, do.	6	15	0	,,	,,	,,
Do. mrch. Tyne or Tees do.	6	10	0	,,	,,	,,
Do. railway, in Wales, do.	6	12	6	7	0	0
Do. Swedish in London do.	9	15	0	,,	,,	,,
To arrive do.	9	12	6	,,	,,	,,
Pig No. 1 in Clyde do.	2	18	6	3	5	6
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. No. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	10	0	5	15	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pig in London do.	6	0	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	13	10	0	13	15	0
Do. (hammered) do.	14	15	0	,,	,,	,,
Do. in faggots do.	15	15	0	16	0	0
English spring do.	17	0	0	23	0	0
QUICKSILVER, per bottle	6	17	0	,,	,,	,,
LEAD.						
English pig, common, per ton	18	5	0	,,	,,	,,
Ditto. L.B. do.	18	5	0	18	10	0
Do. W.B. do.	19	0	0	,,	,,	,,
Do. sheet, do.	18	15	0	,,	,,	,,
Do. red lead do.	20	0	0	20	10	0
Do. white do.	27	0	0	30	0	0
Do. patent shot do.	22	0	0	,,	,,	,,
Spanish do.	17	15	0	,,	,,	,,

*At the works 1s to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, add resse or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated April 22nd, 1870.

1168 E. Farrington—Firearms
1169 J. Gray—Ploughs
1170 C. T. Bousfield—Mowing and reaping machines
1171 J. R. Clark—Knitting stockings
1172 C. Bardy and L. Dusart—Producing colouring matters
1173 J. A. Wade and J. Cherry—Roofing tiles and fastening them together
1174 G. W. Cooke and H. Kennedy—Securing ridges of slate
1175 H. Shaw—Hulling cotton
1176 W. Gossage—Decomposition of certain metallic sulphides
1177 G. Little—Combing cotton
1178 V. Milward—Wrappers for papering needles, &c.
1179 M. M. Silber—Moderator lamp
1180 C. Lungley—Securing of tubes, &c.

Dated April 23rd, 1870.

1181 T. Feather—Slubbing worsted, &c.
1182 G. Bernhardt—Spinning, &c.
1183 C. H. Savory and W. R. Barker—Effecting fumigation
1184 J. P. Ferris and E. Craddock—Generating illuminating gas
1185 L. C. Schermerhorn and C. Schermerhorn—Cheese
1186 P. Spence—Potash, &c.
1187 M. Brown-Westhead and R. Smith—Folding tapes
1188 M. Bayliss—Spikes
1189 W. Thompson and T. Stather—Mills for grinding cattle food
1190 A. Morand—Kilns or ovens

Dated April 25th, 1870.

1191 S. D. Tillman—Boilers, &c.
1192 G. Fenwick—Ropes or cables
1193 F. D Sutherland—Portmanteaus
1194 E. L. Parker—Buckles
1195 J. Lord, J. Gresty, and C. Cross—Separating cotton
1196 S. and J. Randall—Harrows
1197 G. J. Firmin—Liquid gauges
1198 L. Wray—Crushing ores, &c.

Dated April 26th, 1870.

1199 T. Wright and I. Fox—Lace
1200 L. Schad—Treating human excrement
1201 R. Birkin—Ornamented net
1202 Sir W. F. Cooke and G. Hunter—Stone cutting apparatus
1203 H. Fletcher—Boot heels, &c.
1204 H. Y. D. Scott—Cement
1205 H. Y. D. Scott—Bricks
1206 J. Palmer—Stoves
1207 A. Browne—Steam boilers

Dated April 27th, 1870.

1208 T. Wrigley—Looms
1209 W. E. Gedge—Rolling mills
1210 H. Atkinson—Breech loading needle guns
1211 W. Hart—Heels for boots
1212 E. Wigzell and J. Pollit—Improvements in steam engines
1213 F. J. Ortner—Arrangement of pipes for drawing liquids from casks
1214 E. Vimaux—Musical instruments
1215 C. Wood—Absorbing the overflow of oil in lamps
1216 H. E. Curtis—Cylinder engines
1217 J. Burnley and W. Nichols—Steam boilers and furnaces
1218 J. Underwood—Stoppering the necks or openings of bottles
1219 W. R. Lake—Cleaning wool

Dated April 28th, 1870.

1220 R. H. Kay and A. T. Richardson—Manufacture of crape
1221 W. Germain—Earrings
1222 W. J. Blinkhorn—Sewing machines
1223 J. Lee—Motive power
1224 P. Smith, J. H. Leather, and E. D. A. Marriner—Preparing wool
1225 R. B. Hamel and J. B. Holden—Mechanism for transmitting power
1226 A. V. Newton—Apparatus for starting treadle motions
1227 C. W. Alden—Pipe wrenches

Dated April 29th, 1870.

1228 M. Jefferson—Preparing wool, &c.
1229 T. Thorpe—Piled fabrics
1230 J. M. Clark—Soldering tin cases
1231 T. Empson—Improved button
1232 E. W. Buller—Attaching door knobs to spindles, &c.
1233 F. Ransome—Artificial stone
1234 H. E. Curtis—Cutting slate
1235 R. H. Collyer—Machinery for breaking, &c., flax

Dated April 30th, 1870.

1236 W. Sketchley—Propelling boots
1237 D. Mills—Guiding the work in machines for sewing boots
1238 I. and G. Bettinson—Machinery for combing wool, &c.
1239 A. C. Henderson—Breaking and crushing stones, &c.
1240 V. Bablon—Regulating the pressure of gas in gas burners
1241 A. Evans—Vase
1242 B. Massi—Locks and keys
1243 W. H. Gosling—Sewing machines
1244 W. R Lake—Spring fastening for securing purses, &c.
1245 O Murrell—Generating steam
1246 C. N. A. Collett—Counting machines

Dated May 2nd, 1870.

1247 J. H. Kidd—Shoes for horses
1248 J. Christie—Cutting and clipping the lappet of cloth
1249 S. W. Staubridge—Preparation of malt for brewing
1250 E. Lowe and H. J. Farnol—Nails
1251 T. Paton—Steam engines
1252 W. R. Lake—Valve
1253 W. Nunn—Signal lamps
1254 H. Beare—Pulverising and distributing guano and artificial manure
1255 A. V. Newton—Bale ties
1256 W. Anderson—Improved arrangement of gearing for mills
1257 J. Jennings—Hoisting machine
1258 J. Leetch—Combined self closing stopper and whistle
1259 E. R. Wetherhed—Saving life and property from fire

Dated May 3rd, 1870.

1260 A. Barlow—Textile fabrics
1261 P. J. Livsey—Printing upon spools used for holding thread
1262 J. A. Emslie and T. Emslie—Lifting or conducting liquids, &c.
1263 H. Belmont—Tilling land
1264 T. Bradbury and J. Bamford—Communication between passengers, &c., on railways
1265 J. Ormerod—Looms
1266 S. Taylor—Rack pulleys
1267 E. P. North—Supports for adjusting umbrellas, &c.
1268 W. H. Preece and W. E. Langdon—Railway signals
1269 J. Tiranoff—Preventing railway carriages running off the line
1270 A. M. Clark—Traction engines
1271 J., C. J., and F. S. Guy—Apparatus for copying letters
1272 G. Wright—Brick making machines
1273 A. M. Clark—Steam carriages

Dated May 4th, 1870.

1274 W. Woodward and A. Woodward, jun.—Manufacture of gas
1275 C. P. Matthews—Compound for the inside of casks
1276 W. N. Hutchinson—Rails of railways and tramways
1277 W. C. Rawlins and A. Knowles—Reversing gear
1278 C. Exter—Improved brake
1279 H. Kinsey—Wheels
1280 B. Walker and J. F. A. Pflaum—Machinery for puddling
1281 J. Campbell—Drawing flax
1282 F. M. Blyth—Harvesting machines
1283 B. Burton—Firearms

Dated May 5th, 1870.

1284 G. Ingram—Regulating the lift of carriage windows
1285 J. B. Hickmott—Gas
1286 W. R. Lake—Steam engines
1287 A. V. Newton—Cleaning grain
1288 J. H. Johnson—Improvements in treatment of maize
1289 J. H. Johnson—Safes, &c
1290 T. Ellis—Furnaces
1291 F. Hart—Planes for chamfering and moulding
1292 J. and M. May—Spinning wool and other fibres
1293 W. Thornton—Gaiters, &c.
1294 W. Brough, sen, and W. Brough, jun.—Ovens and kilns

Dated May 6th, 1870.

1295 A. Ripley—Pipe wrench
1296 E. Clark—Improvements in constructing piers
1297 R. Leake—Etching or engraving rollers for calico printers
1298 J. Tester—Cutting chaff
1299 D. Walker—Preventing the production of smoke
1300 E. T. Kirkpatrick—Oxygen gas
1301 W. Thompson—Recording electric telegraph signals
1302 S. C. Lister—Double pile fabrics
1303 A. H Macnair—Permanent way
1304 T. Don—Improvements in obtaining and applying heat

Dated May 7th, 1870.

1305 W. T. Blake and M. Hyams—Sanitary construction of tobacco pipes
1306 H. Brooke—Drain pipe rest
1307 F. R. A. Glover—Steering ships and other vessels
1308 W. S. Lowe—Tape dressing machines
1309 J. Nixon and J. Winterbottom—Piercing tangs for table knives
1310 J. Bullough—Sizing machines
1311 R. Weare—Receiving and treating sewage and other noxious matters
1312 L. Mond and J. Hargreaves—Manufacture of chlorine
1313 W. R. Lake—Stamping apparatus
1314 A. P. Price—Treatment of sewage and production of manures
1315 E. Guenin—Mustard plasters

Dated May 9th, 1870.

1316 B. Bert—Basin for breeding oysters
1317 D Brown—Dressing flax
1318 G S Penny—Stereoscopes
1319 J. Speight—Machinery for spinning worsted, &c.
1320 J. I. Evans—Brushing machine
1321 E Whitworth—Rotary engines
1322 T. Banks—Needle wrapper
1323 B. Hunt—Method of securing screw bolts and nuts
1324 J. Pepper—Machinery for knitting looped fabrics
1325 H. M Ward—Spinning flax, &c.
1326 C. Bro k—Thread

Dated May 10th, 1870.

1327 E. A. Inglefield—Improvements in steering tell-tales
1328 H. Johnson and R. J. Lecky—Locking screw bolts
1329 B. H. Chameroy—Cocks
1330 H. Aitken—Breaking up or pulverising lumps of soil
1331 W. Hunt—Detergent compound
1332 J. Jones and E. R. Dunn—Alloy for the bearings of shafts, &c.
1333 B J. Edwards—Photographic printing
1334 W. Dangerfield—Walking sticks and sticks for umbrellas
1335 W. R. Lake—Gas
1336 W. R. Lake—Brewing ale and other malt liquors

Dated May 11th, 1870.

1337 F. Broughton—Perforated fire bars applicable to locomotive boilers
1338 P. R. Jackson—Construction of segmental toothed wheels
1339 A. A. Rossignol—Writing music
1340 H. A. Dufreue—Water meter
1341 T. W. Wedlake—Improvements in steam engines
1342 J. Crouzieres—Gas and water tight joint to pipes
1343 J. Howard—Signal lamps
1344 T. J. Guy—Apparatus for facilitating travelling on foot
1345 W. R. Lake—Paddle wheels
1346 J. Nicholson and J. W. Jones—Fastenings for windows
1347 C. W. Harrison—Applying electricity on board ships, &c.
1348 E. Smith—Locking nuts
1349 W. E. Rendle—Glazed structures for horticultural purposes
1350 F. Perry—Preservation of meats
1351 W. E. Newton—Machinery for pointing and finishing nails
1352 E. P. H. Vaughan—Construction and working of gas engines

Dated May 12th, 1870.

1353 L. W. Weeks—Ball floats
1354 G. W. Wigner—Deodorising and purifying sewage
1355 L. O. Deschamps and S. D. Ondlt—Cutting net
1356 J. F. Rogers—Fuse
1357 W. E. Newton—Construction of steam valves or cocks
1358 J. H. Johnson—Improved construction of grate bars
1359 A. Campbell—Destroying vermin or disease in sheep
1360 J H. Johnson—Projectiles
1361 C. Churchill—Window fastener
1362 G. Fawcus and G. Lunge—Coatings for iron ships

Dated May 13th, 1870.

1363 H. Law—Meters, &c.
1364 W. Daniell and H. Lund—Electro magnetic engine
1365 W. E. Gedge—Steam machine
1366 J. W. Elliot—Removing snow from railway tracks
1367 T. Perkins—Ploughing land
1368 W. Young—Crates
1369 J. Miller and J. Miller, jun.—Elastic fabrics for gussets
1370 T. Coles and W. Henderson—Scutching flax other fibres
1371 J. Heddle—Preparing and preserving vegetable juices
1372 A. McAlister—Hammocks
1373 E. G. Peacock—Apparatus for refrigerating and heating
1374 J. A. Gardner—Signalling between passengers, guards, &c.
1375 W. E. Newton—Improvements in construction of vessels
1376 J. Dodd—Spinning, &c.
1377 T. B. Gilbert—Fire escapes

Dated May 14th, 1870.

1378 R. Mellard—Pressing machines
1379 P. Pimont—Composition for preserving the surfaces of walls
1380 C. R. Simey—Stuffing boxes
1381 J. J. Hignette—Dressing, glazing, and pearling rice
1382 A. Ormson—Warming and ventilating horticultural buildings
1383 W. R. Lake—Sewing machines
1384 F. N. Meixner and J. Watmough—Heating water
1385 P. Jensen—Writing hall
1386 J. Warne—Vessels for cooling
1387 L. Turner—Elastic fabrics
1388 A. Fisher—Dyeing yarns
1389 J. B. Handyside and T. R. Yarrow—Springs
1390 B. Hunt—Shirts
1391 R. H Murray—Casting mould boards
1392 C. Wicksteed—Filling water carts

Dated May 16th, 1870.

1393 G. G. de L. Byran—Washing
1394 G. W. Hemans—Recovery of sulphuric acid spent in refining petroleum
1395 H. A. Biertumpfel and J. Loveday—Shaping wood
1396 A. and G. Sauer and L Cachal—Raising paste or dough
1397 W. Gilbey—Case fastener
1398 T. Fawcett—Sawing machinery
1399 R. L Hattersley—Beaming warps
1400 J. H. Banks—School furniture
1401 J. H. Johnson—Bearings, slides, and packings for steam engines
1402 A. Pocock—Enabling persons to drink in a recumbent position
1403 J. Yates—Taps
1404 J. Needham—Ships
1405 A. W. C. Williams and C. M. Talcott—Lawn mowing machines
1406 D. Smith—Furnaces
1407 T. Page | Apparatus for subaqueous works

Dated May 17th, 1870.

1408 J L. Montefiore—Bronze
1409 E. F. Jones—Iron
1410 C. Hunt—Retorts
1411 J. H. Player—Phosphorus
1412 H. B. Greenwood—Holding window sashes or shutters
1413 M. Benson—Pumping engines
1414 J. Agnew—Preparation of cod liver oil, called cod liver oil jelly
1415 B. Hunt—Paints
1416 E. Green—Steam boilers
1417 B. Birnbaum—Stay fastenings, &c.
1418 F. J. Cleaver—Moulding and stamping soap
1419 B. Lawrence—Inks
1420 T. G. Webb—Ornamenting glass articles
1421 G. Nelson—Raising, lowering, and detaching ships' boats

Dated May 18th, 1870.

1422 H. van Laethem—Dial universal
1423 T. P. Young and J. Thomasson—Looms
1424 G. Hodgkinson—Table covers
1425 J. Casteiaz—Artificial alkaloids
1426 J. G. Charlick—Securing cash boxes
1427 W. Woller—Furnaces
1428 D. M. Weston—Knitting goods
1429 W. E. Newton—Automatic barrel filling apparatus
1430 J. Starley—Sewing machines
1431 W. R. Lake—Looms for weaving
1432 W. Brodie—Vehicles used on railways
1433 G. R Turner—Winnowing machines
1434 F. Edwards—Lace
1435 E. Peyton—Welded iron or steel tubes
1436 E. Peyton—Metallic bedsteads
1437 G. T. Bousfield—Looms
1438 A. M. Clark—Cigars

Dated May 19th, 1870.

1439 J. Steart—Cleansing ships' bottoms
1440 J. Diggle and H. Booth—Looms
1441 B. C. Muzzall—School furniture
1442 S. Baerlein—Doubling cotton
1443 J. and J. Smithers—Woven fabrics
1444 W. E. Gadge—Steam engines
1445 G. Zanni—Telegraphic apparatus
1446 J. A. and J. Hopkinson—Regulating the supply of air to furnaces
1447 R. Oxland—Sulphuric acid
1448 G. W. Rendel—Cartridges
1449 R. Pitt—Valves
1450 J. Schloss—Purse fastenings
1451 W. R. Lake—Machines for lapping cotton
1452 J. Baird—Treating oils
1453 W. L. Mitchell—Looms
1454 J. P. Blake—Rolling wire
1455 J. Breeden—Pumps
1456 A. M. Clark—Production of gases for heating and lighting
1457 M. Girand—Tilling land
1458 J. H. Johnson—Preserving butter

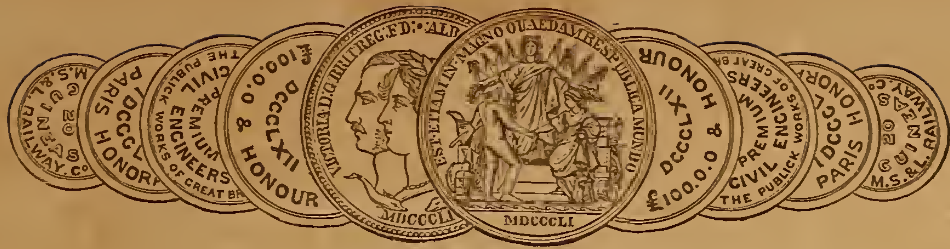
Dated May 20th, 1870.

1459 G. H. M. Hardingham—Tobacco pipes
1460 A. Taylor—Rocket projectiles
1461 T. Hodson—Piled fabrics
1462 T. J. Smith—Diminishing the friction of axles
1463 J. J. Denoual—Enveloping liquids
1464 D. C. Lowber—Securing bale of goods
1465 W. Barwell and G. B. Smith—Securing the nuts of screw bolts
1466 H Osterkamp—Rock drill
1467 A M. Silber and F. White—Lighting
1468 G. Fischer—Steam boiler firing with complete smoke combustion

Dated May 21st, 1870.

1469 R. Harte—Aerial locomotion
1470 J A. R. van den Bergh—Sea messenger for receiving papers.
1471 G. Simpson—Arrangements for cutting or getting stone
1472 T. H. Lloyd—Regulating the supply of steam and water
1474 P. and T. W. Webley—Breech loading firearms
1475 E. E. Allen—Tramways and in engines used thereon
1476 F. J. Tellier—String
1477 H. Hind and G. Wells—Steam and other valves
1478 B. Perowne—Machinery for cutting turnips and other roots
1479 F. Milnes—Healthily exercising the human frame

GREAT MEDAL, 1851.



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LATTICE BRIDGE WORK (Strain taken off Rivets); also IMPROVED IRON AND STEEL PLATE BRIDGES.
CORNISH BOILERS (less in cost, carriage, and fuel, and not so liable to explosion).
DITTO, OLD ONES, or those in use easily altered and improved, or taken in exchange.
MARINE ditto, to work when the ship is half filled with water, or in great distress.
VERTICAL and other Portable Land Boilers, Tanks, Roofs, &c.
EMIGRANTS' HOUSES, Iron, Zinc, Waterproof, &c., Imitation of Bricks Stone, Tiles, &c.
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Nine-tenths of the Amount may remain at Interest, or be exchanged for paid-up Shares in such Company.

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T. DUNN.

This Circular is addressed to all Persons interested in Railway Property.

TO ENGINEERS, CONTRACTORS, LOCOMOTIVE ENGINE, CARRIAGE, AND WAGGON BUILDERS, &c.

It has been remarked by many Railway promoters, and practical financiers, that the more economy is observed and effected, the more prosperous and progressive Railways and their tributaries will become.

The Author begs to submit two of his plans for avoiding Oscillation, now very detrimental to Rolling Stock and Permanent Way.

Fig. 1 is a diagram showing the usual plan of Engine, with a cylinder placed on each side of the centre line; steam being applied behind one piston and in front of the other, the pressure of which is indicated by the arrows A and B, and which evidently throws the engine with equal force in the direction of the arrows D D. The weight of the engine, and the cone of the wheels, take off some of the shock, but not always sufficient to prevent the flange of the wheel striking the rail with violence, and *vice versâ* when the steam is admitted on the opposite side of the pistons. This causes a continuous oscillation the whole journey throughout the full length of the train, producing very heavy wear and tear, and sometimes throwing the engine and carriages off the line.

Fig. 2 is a diagram of one of my improved Engines, showing three cylinders. The centre one is of the usual size, and the two outer ones are each half the area of the centre one, and act together at right angles, or nearly so, with the main central crank. The steam, being applied in the direction of the arrows A and B B, it is evident that there is no side throw, or oscillation caused, whatever way the steam may be acting, or in reversing.

Fig. 3 is a diagram of another of my improved Engines, showing two steam cylinders, one opposite the other, on the centre line. This arrangement also causes no side thrust, or oscillation, which ever way the steam may be acting on the pistons. These cylinders may also be placed over each other to work from one end of the engine, and for greater convenience of coupling the wheels. Central coupling cranks are also used, which are not shown in these diagrams, and many other arrangements which will be found in my Patent, of the 27th of October, 1869, No. 3108.

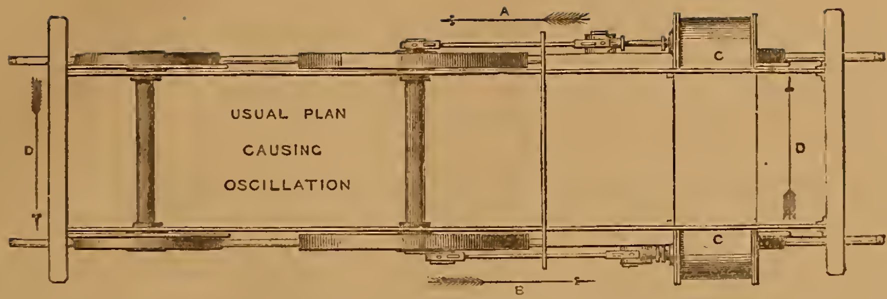
Your very faithful and obedient Servant,

P.S. Any further information, supplied on application, either personally or by letter.

Thos Dunn

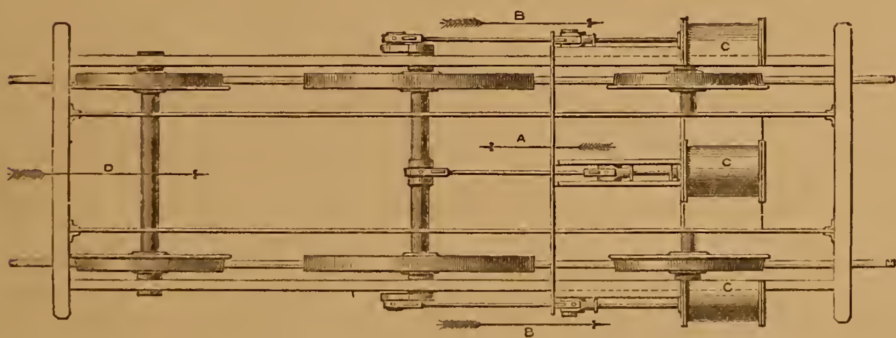
50, Withington Street, Pendleton, Manchester.

Fig. 1.



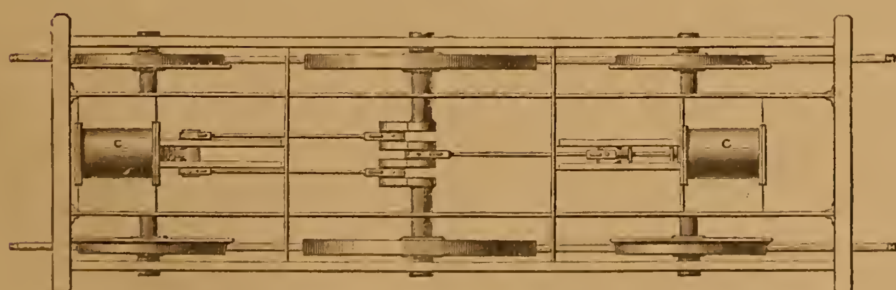
General mode of placing Cylinders of Locomotive Engines.

Fig 2.



DUNN'S PATENT PLANS AVOIDING OSCILLATION

Fig. 3.

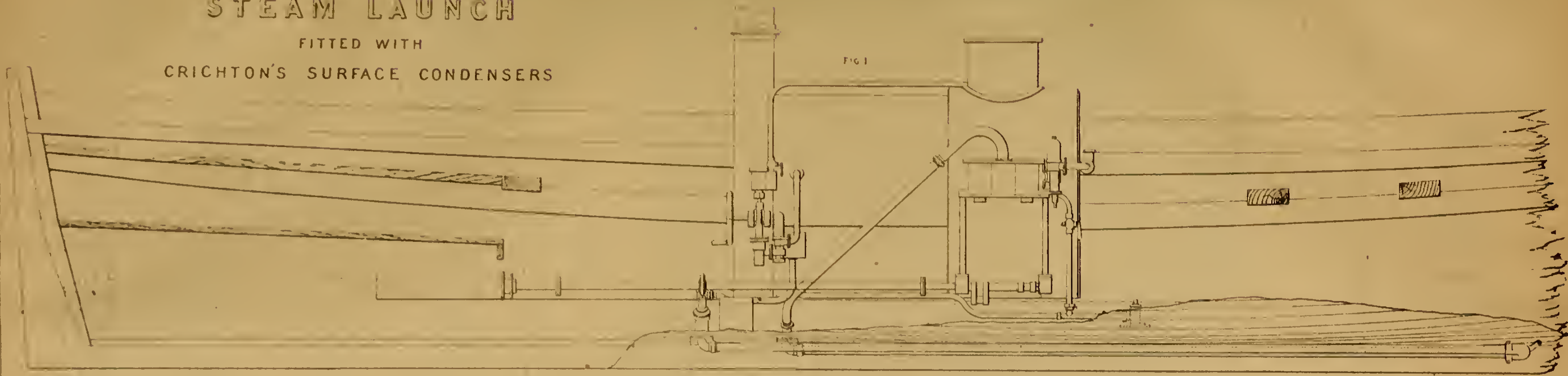


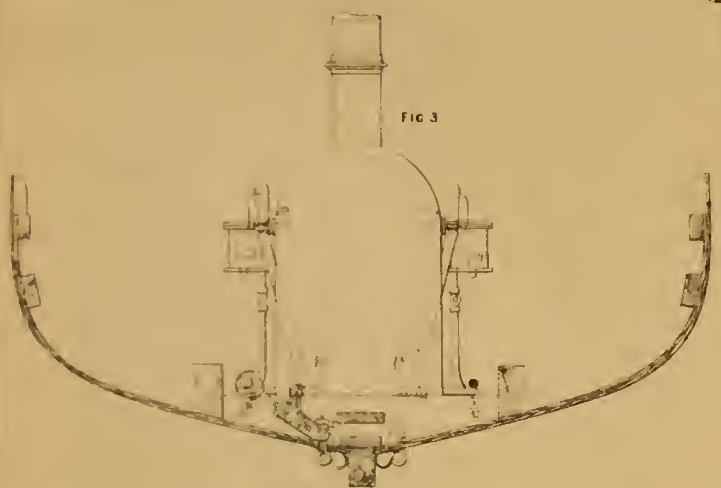
These Improvements are particularly adapted to Narrow Gauge Railways, and Engines of High Velocities on Wide Gauges.

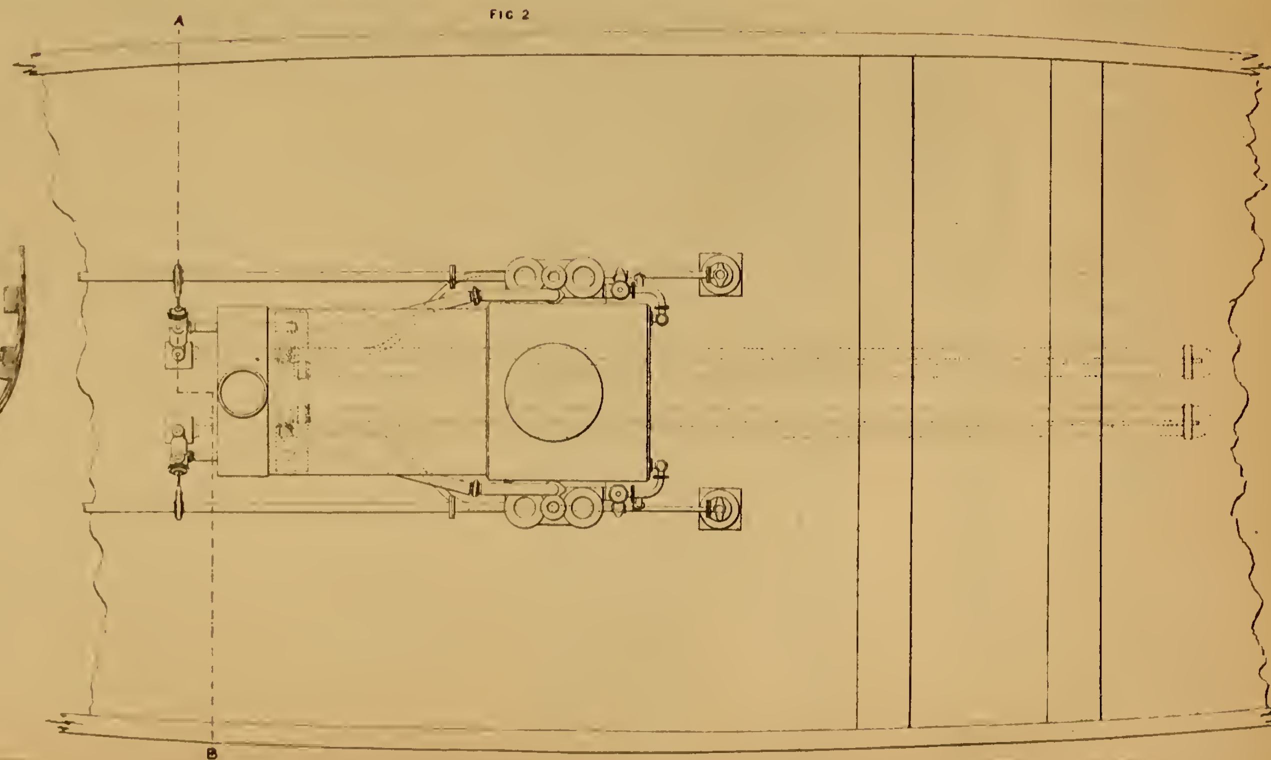
STEAM LAUNCH

FITTED WITH

CRICHTON'S SURFACE CONDENSERS







P. Soames A.K.C. direx

THE ARTIZAN.

No. 7.—Vol. IV.—Fourth Series.—Vol. XXVIII. From the Commencement.

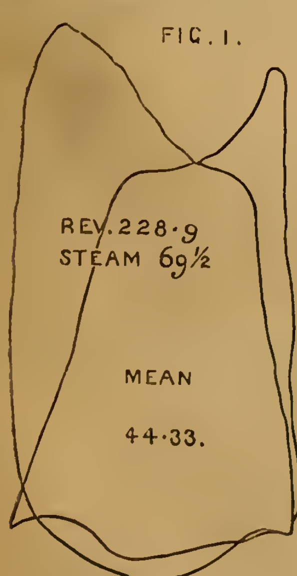
1st. JULY, 1870.

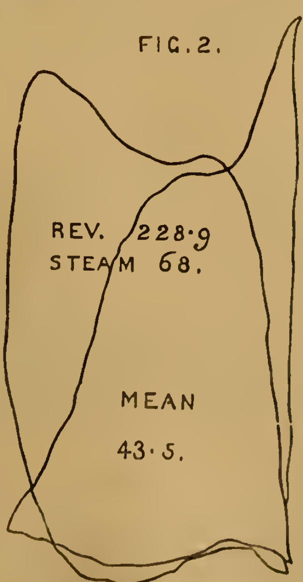
STEAM LAUNCH FITTED WITH CRICHTON'S SURFACE CONDENSERS.

(*Illustrated by Plate* 362).

In The Artizan of last May, there was given a description, accompanied by a plate (360), of a simple method of condensing steam adapted for steam yachts and other small steam vessels fitted with high pressure engines. The advantages resulting from condensing the steam and returning pure water to the boiler, instead of blowing it up the funnel were there pointed out; moreover, they are so generally acknowledged, that we need not further enlarge upon them. In order, however, to give our readers a choice of methods by which this desirable result may be obtained, we now illustrate, in Plate 362, a very convenient arrangement that has been invented by Mr. Alexander Crichton, engineer to the Cork Steam Ship Company, and applied to two launches, viz.: one attached to H.M.S. *Lord Clyde*, and the other to H.M.S. *Cambridge*.

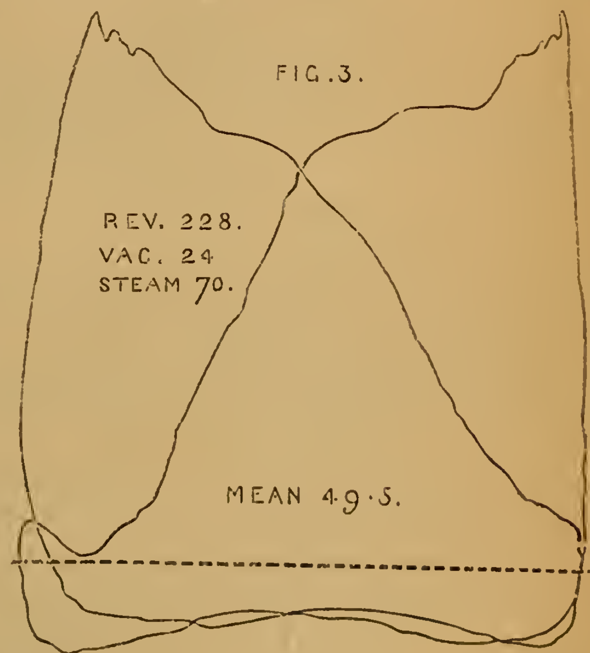
The arrangement illustrated in Plate 360 was intended simply to condense the steam, and return the pure water so obtained into the boiler, for which purposes it is admirably adapted, but without any attempt at forming a vacuum. In the plan now illustrated by Plate 362, not only are these advantages obtained, but in addition a very fair vacuum is kept up, thus forming a complete condensing engine out of one originally intended to work non-condensing. In Plate 362, Fig. 1 is an elevation, Fig. 2 a plan, and Fig. 3 a transverse section on the line A B, of Mr. Crichton's arrangement, as applied to the steam launches attached to H.M.S.'s *Lord Clyde* and *Cambridge*. It consists in the exhaust pipes from the engines, which formerly discharged into the funnel, being now turned downwards, when passing out through the bottom of the boat, they are then carried forward





alongside the keel, the length of 14ft. Then afterwards returning a distance of 16ft., they re-enter the boat, and are connected to the bottoms of small air pumps, which are worked by eccentrics off the screw shafts, the boats being fitted with two pairs of engines and twin screws. The air pumps discharge into a small vessel or hot well, to which the suction pipes of the feed pumps are attached.

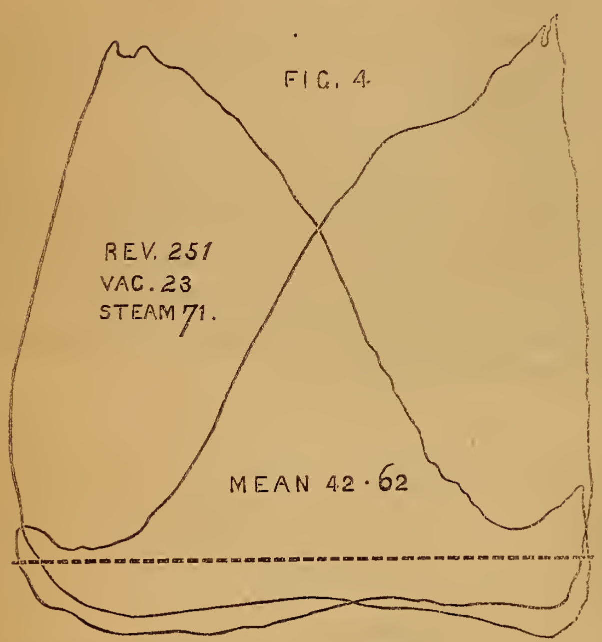
By means of this simple arrangement, a vacuum of 24in. or of 12lbs. per square inch is obtained when working with 70lbs. steam in the boiler. Previous to the application of the condensing apparatus it was necessary to carry a supply of fresh water in tanks on board the boats, for feeding the boiler when working in salt water. The weight of tanks and water carried for this purpose, but now removed being no longer required, is 1 ton 19 cwt., and the space occupied in each boat was about 40 cubic feet. The total weight of the condensing apparatus is under 4 cwt., and it occupies no appreciable room in the boat.



In boats fitted with only one pair of engines and a single screw, the condensing apparatus is much simplified, as the two exhaust pipes meet into one inside the boat, which passing through the bottom, runs along one side of the keel and then passes through it, and up along the other side, when it re-enters the boat and is connected to a single air pump.

We have already, in a former article upon the subject, pointed out most of the advantages resulting from condensation, such as obtaining a regular feed with clean water, and preventing the unpleasant noise created by the escape of the steam up the funnel. In the class of boats now under consideration, however, it is obvious that the noise from the waste steam is not only a nuisance, but is absolutely a fatal objection to their employment for many purposes for which they would otherwise be of the utmost value. Thus, nothing could be more useful than a fast, handy little steam launch for reconnoitring purposes, or for secret service, if the sight of the waste steam by day, or its sound by night, did not betray its presence. It is obvious, therefore, that for use in H.M.'s Navy, the adoption of an effectual system of condensation is not only desirable, but absolutely imperative.

In order to give our readers some idea of the working of this system of condensation, we now give a drawing of a pair of indicator diagrams taken from the steam launch attached to H.M.S. *Lord Clyde*. Figs. 1 and 2 were taken from the port and starboard engines respectively when non-condensing, while Figs. 3 and 4 were taken from each engine when condensing. At the time when the two first diagrams Figs. 1 and 2 were taken, the pistons travelled 3⅝in. before the steam was cut off, the length of stroke



being 6in., but when the diagrams Figs. 3 and 4 were taken, the steam was cut off when the pistons had only travelled 2⅝in. Now, as the mean pressure is rather greater when condensing, it is evident that there must be a considerable saving of fuel effected thereby. We understand that Mr. Crichton was anxious to have had some further trials to ascertain the actual amount of saving thus effected, but the authorities at the Admiralty expressed themselves as sufficiently satisfied, and declined to make any further trials.

ON THE THERMAL ENERGY OF MOLECULAR VORTICES.

By W. J. Macquorn Rankine, C.E., LL.D., F.R.SS.L. & E., &c.

1. Object of this Paper.—In a paper "On the Mechanical Action of Heat," which I sent to the Royal Society of Edinburgh in December, 1849, and which was read in February, 1850, it was shown that if sensible or thermometric heat consists in the motion of molecular vortices supposed to be arranged in a particular way, and combined in a particular way with oscillatory movements, the principles of thermodynamics and various relations between heat and elasticity are arrived at by applying the laws of dynamics to that hypothesis. The object of the present paper is to show how the general equation of thermodynamics and other propositions are deduced from the hypothesis of molecular vortices, when freed from all special suppositions as to the figure and arrangement of the vortices and the properties of the matter that moves in them, and reduced to the following form:—That thermometric heat consists in a motion of the particles of bodies in circulating streams with a velocity either constant or fluctuating periodically. This, of course, implies that the forces acting amongst those particles are capable of transmitting that motion.

2. Steady and Periodical Component Motions.—A vortex, in the most general sense of the word, is a stream or current which circulates within a limited space. Conceive a closed vessel of any figure and volume to be filled with vortices or circulating streams, the mean velocity of circulation in each such stream being the same, and let the velocities of the moving particles be either constant or periodic. How complex soever those motions may be, they may be resolved into the following component motions—a motion of steady circulation with the uniform velocity already mentioned as the mean velocity, and a motion consisting in periodical fluctuations of velocity. Those two component motions may be called respectively the steady circulation and the disturbance.

3. Mean Pressure due to Centrifugal Force.—Let an elementary circulating stream—that is, a circulating stream of indefinitely small sectional area—be supposed to flow round and round in an endless tube with the uniform velocity w; let ρ denote the density of the stream, $d\,\sigma$ the sectional area. Consider two cross sections of the stream at which the directions of motion of the particles are contrary, and consider what resultant forces are exerted by the stream on the two parts into which those two cross sections divide the tube. The mass of matter which flows through each cross section of the tube in a unit of time is

$$\rho\, w\, d\,\sigma,$$

and in each unit of time a mass of matter of that amount has its velocity reversed. The force required in order to produce that reversal of velocity is of the following amount in absolute units,

$$2\,\rho\, w^2\, d\,\sigma,$$

and such is the amount of each of the pair of inward pressures which the tube exerts on the stream, and of each of the pair of equal and opposite outward pressures exerted by the stream on the tube, tending to pull it to pieces. It may be called the centrifugal tension of an elementary stream.

The velocity of the particles flowing in the stream may undergo periodical fluctuations, positive and negative alternately; these will cause periodical variations in the centrifugal tension, but the mean value of that tension will continue to be that given by the formula.

The mean intensity of the centrifugal tension, in a direction tangential to the stream, is found by dividing the amount given by the preceding expression by the collective area, $2\,d\,\sigma$, of the two cross sections, giving the following result—

$$\rho\, w^2.$$

Suppose now that the stream is cut by an oblique sectional plane, making the angle θ with a transverse section. Then the area of that oblique section is greater than that of a transverse section in the ratio of $1 : \cos\theta$; and the amount of the component tension in a direction normal to the oblique section is less than that of the total centrifugal tension in the ratio of $\cos\theta : 1$; whence it follows that the mean intensity of the component centrifugal tension in a direction making an angle θ with a tangent to the stream is

$$\rho\, w^2 \cos^2\theta.$$

Next, suppose a vessel of any invariable volume and figure to be filled with vortices or circulating streams, the velocity of steady circulation being w, and the mean density ρ. The centrifugal force will cause a pressure to be exerted in all directions against the inside of the vessel. To determine the mean intensity of that pressure irrespectively of periodical variations, conceive the contents of the vessel to be divided into two parts by an imaginary plane, and consider what will be the mean intensity of the force with which the circulating streams tend to drive asunder the portions of matter at the two sides of that plane. The plane will cut the streams that flow across it, some normally, others obliquely; and the tangents to those streams will have all possible directions relatively to a normal to the plane, subject to the condition, in the case of isotropic action, that the mean value of $\cos^2\theta$ must be the same for all positions of the plane. But the sum of the mean values of $\cos^2\theta$ for three planes at right angles to each other must be $= 1$; therefore the mean value of $\cos^2$ is $= \frac{1}{3}$ and, finally, the mean intensity of the centrifugal pressure is given in absolute units per unit of area by the equation

$$p = \frac{\rho\, w^2}{3} \quad \text{.......} \quad (1)$$

4. Energy of Steady Circulation compared with Centrifugal Pressure.—The actual energy of the steady circulation in a unit of volume is expressed in absolute units of work as follows:—

$$\frac{\rho\, w^2}{2} \quad \text{.......} \quad (2)$$

which, being compared with equation (1), gives the following result:—

$$p = \frac{\rho\, w^2}{3} = \frac{2}{3} \cdot \frac{\rho\, w^2}{2}; \quad \text{.......} \quad (3)$$

that is to say, the intensity of the centrifugal pressure on the unit of area is two-thirds of the energy of the steady circulation in a unit of volume. This is one of the propositions of the Paper of 1849–50, p. 151, eq. v.; but it is now shown to be true, not merely, as in the former paper, for molecular vortices arranged in a particular way, but for molecular vortices arranged in any way whatsoever, provided their action is isotropic and their mean velocity uniform.

A similar proposition has been proved by Waterston, Clausius, Clerk Maxwell, and others, for the pressure produced by the impulse of small particles flying about in all directions within a closed vessel and rebounding from its sides.

5. VORTICES WITH HETEROTROPIC ACTION.—It is conceivable that, in solid bodies, molecular vortices may be so arranged as to produce centrifugal pressures of different intensities in different directions. In such cases it is to be recollected that the sum of the mean values of $\cos^2 \theta$ for the obliquities of any set of lines to any three plates at right angles to each other is $= 1$; whence it follows that if p', p'', p''' be the mean intensities of the centrifugal pressures in any three orthogonal directions, we have

$$p' + p'' + p''' = \rho w^2; \quad \ldots\ldots\ldots\ldots \quad (4)$$

that is to say, the sum of the mean intensities of the three centrifugal pressures in any three orthogonal directions is equal to twice the energy of the steady circulation in a unit of volume. This proposition was not in the Paper of 1849–50, which was confined to an isotropic arrangement of vortices.

6. ENERGY OF THE PERIODICAL DISTURBANCES.—In the Paper of 1849–50, p. 152, eq. x., the energy of the periodical disturbances was taken into account by multiplying the energy of the steady circulation by a factor k greater than unity, thus giving for the total energy in a unit of volume the following expression,

$$\frac{\rho v^2}{2} = \frac{k \rho w^2}{2};$$

in which v^2 denotes the mean of the squares of the resultant velocities of the particles with their combined motions. The values of the factor k, being the ratio which the total energy of the molecular motions bears to the energy of the steady circulation, are to be deduced in each case from the results of experiments on specific heat.

Thus the energy of the disturbances in a unit of volume is expressed by,

$$(k - 1) \frac{\rho w^2}{2} = \frac{3}{2} (k - 1) p \quad \ldots\ldots\ldots\ldots \quad (5)$$

It may now be observed in addition that the energy of the disturbances may, and indeed must, be at times partly potential as well as actual—in other words, partly due to displacement as well as to fluctuation of velocity.

Let $\pm u$ be the greatest fluctuation of velocity; then a particle of the mass unity has the energy $\frac{u^2}{2}$ due to that fluctuation, in addition to the energy due to the steady circulation. It is only at the instants of greatest disturbance of velocity that the energy is all actual; at every other instant the energy is partly potential. Hence $v^2 = k w^2$ may be taken to denote, not the square of an actual velocity common to all the particles, but the value to which the square of the velocity of the particles, would rise if all the energy of the disturbances, actual and potential, were expended in increasing the velocity of steady circulation.

7. TOTAL ENERGY OF THERMAL MOTIONS.—The total energy of the motion compounded of steady circulation and periodical disturbances, in a unit of volume, is expressed, as in the Paper of 1849–50, by the following equation, which also shows its relation to the centrifugal pressure,

$$\frac{k \rho w^2}{2} = \frac{3 k}{2} p \ldots\ldots\ldots\ldots \quad (6)$$

in which (to recapitulate the notation) ρ is the mean density, w the velocity of steady circulation; the centrifugal pressure p is expressed in absolute units of force on the unit of area; and the proportion k, in which the total energy of thermal motions exceeds the energy of steady circulation, is a quantity whose values and laws are left to be deduced from the results of experiment.

8. DETERMINATION OF CENTRIFUGAL PRESSURES.—The external pressure exerted by any substance, as we find it in Nature, is a complex quantity, being compounded of the centrifugal pressure already mentioned, and of forces which may be classed together under the name of cohesion. To enable us to distinguish these components of the total pressure from each other, we have the principle that the centrifugal pressure varies as the density simply; whereas pressure or tension, or stress (to use a general term), arising from cohesive forces, must vary as some function of the density, of a higher order than the first power.

The perfectly gaseous state is an ideal state in which the substance exerts no external pressure except that which varies as the density simply—that is, centrifugal pressure. It is impossible to obtain a substance absolutely in the state of perfect gas; but the cohesive stress diminishes with increase of temperature and diminution of density in such a manner that it is possible, as is well known, to obtain substances approaching very nearly to the perfectly gaseous state, such as atmospheric air and various other gases; and the actual pressures of such nearly perfect gases may be used, either as approximate values of the pressures in the ideal state of perfect gas, or as data for calculating the latter kind of pressures by the method of limits. We thus have the means of determining, to a close approximation, the centrifugal pressure of a given substance at a given temperature and density; the well-known formula being

$$\frac{p}{\rho} = \frac{p_0}{\rho_0} \cdot \frac{\tau}{\tau_0} \quad \ldots\ldots\ldots\ldots \quad (7)$$

in which τ_0 is the absolute temperature of melting ice, τ the actual absolute temperature, and $\frac{p_0}{\rho_0}$ the value of the quotient $\frac{p}{\rho}$ at the temperature of melting ice, for the particular substance in question.

9. TEMPERATURE AND SPECIFIC HEAT.—It is shown in the Paper of 1849–50 that temperature, according to the hypothesis of molecular vortices, is a function of the quotient found by dividing the energy of the steady circulation in a unit of mass by a constant depending on the nature of the substance, which constant may be defined as the value which the energy of steady circulation in a unit of mass of the given substance assumes at a standard temperature, such as that of melting ice. The energy of the steady circulation in a unit of mass is

$$\frac{w^2}{2} = \frac{3}{2} \cdot \frac{p}{\rho};$$

whence it appears that the principle stated as to absolute temperature is expressed by equation (7), already given. The total energy of the thermal motion in a unit of mass is expressed by dividing equation (6) by the density ρ; hence that quantity of energy (denoted for shortness by Q) is given in terms of the absolute temperature by the following equation:—

$$Q = \frac{k w^2}{2} = \frac{3 k}{2} \cdot \frac{p}{\rho} = \frac{3 k}{2} \cdot \frac{p_0}{\rho_0} \cdot \frac{\tau}{\tau_0} \quad \ldots\ldots\ldots\ldots \quad (8)$$

The real specific heat of a substance, as defined in the previous paper, when expressed in units of work per degree, is

$$J c = \frac{d Q}{d \tau} = \frac{3 k p_0}{2 \rho_0 \tau_0} + \frac{3 p_0 \tau}{2 \rho_0 \tau_0} \cdot \frac{d k}{d \tau} \quad \ldots\ldots\ldots\ldots \quad (9)$$

in which c is the real specific heat in terms of the minimum specific heat of liquid water, and J Joule's equivalent, or the dynamical value of the ordinary thermal unit.

There is one part of the specific heat which is necessarily constant for a given substance in all conditions; and that is the part which expresses the rate of increase with the temperature of the energy of the steady circulation alone in a unit of mass, viz.,

$$\frac{d}{d \tau}\left(\frac{Q}{k}\right) = \frac{w^2}{2 g \tau} = \frac{3 p}{2 \rho \tau} = \frac{3 p_0}{2 \rho_0 \tau_0} \quad \ldots\ldots\ldots\ldots \quad (10)$$

The part of the specific heat which depends on periodical disturbances is expressed as follows:—

$$\frac{d}{d \tau}\left\{\frac{(k - 1) Q}{k}\right\} = \frac{3 (k - 1) p_0}{2 \rho_0 \tau_0} + \frac{3 p_0 \tau}{2 \rho_0 \tau_0} \cdot \frac{d k}{d \tau} \quad \ldots\ldots\ldots \quad (11)$$

It is only by experiment that it can be ascertained whether this part of the specific heat is constant or variable. Experiment has proved that it is constant for the perfectly gaseous state, and nearly, if not exactly, constant for other conditions, but that its values for the same substance in the solid, liquid, and gaseous conditions are often different.*

The apparent specific heat contains other terms, depending on the expenditure of energy in performing external and internal work, according to principles of thermodynamics which are now well known.

10. EXAMPLES OF THE PROPORTION IN WHICH THE TOTAL ENERGY OF THE THERMAL MOTIONS EXCEEDS THE ENERGY OF THE STEADY CIRCULATION.—In the perfectly gaseous state, the co-efficient given in equation (9) is the specific heat at constant volume; and as that quantity is known to be constant at all temperatures, the second term of the right-hand side of the equation disappears, and it is reduced simply to the following,

$$J c = \frac{3 k p_0}{2 \rho_0 \tau_0} \quad \ldots\ldots\ldots\ldots \quad (12)$$

The specific heat, in dynamical units per degree, of a perfect gas under constant pressure, is expressed as follows:—

$$J c' = J c + \frac{p_0}{\rho_0 \tau_0} = \frac{p_0}{\rho_0 \tau_0}\left(\frac{3 k}{2} + 1\right) \quad \ldots\ldots\ldots\ldots \quad (13)$$

and the ratio in which the latter co-efficient is greater than the former is therefore

$$\frac{c'}{c} = 1 + \frac{2}{3 k} \quad \ldots\ldots\ldots\ldots \quad (14)$$

whence we have the following formula for deducing the proportion k, from

* According to the nomenclature used by Clausius, the phrase "real specific heat" is applied to that part only of the specific heat which is necessarily constant for a given substance in all conditions. Hence, if that nomenclature were adapted to the hypothesis of molecular vortices, the term real specific heat would be applied to the co-efficient given in equation (10) only, and that given in equation (11) would be considered as part of the apparent specific heat.

by the total energy of the thermal motions to the euergy of the steady circulation, from the ratio, $\frac{c'}{c}$ as determined by experiment,

$$k = \frac{2}{3\left(\frac{c'}{c} - 1\right)} \quad \ldots\ldots (15)$$

This method is applicable only to substances that are nearly in the perfectly gaseous state.

There is another method, applicable to the same class of substances, which is expressed as follows:—

$$k = \frac{2\,p_0\,\tau_0\,J\,c}{3\,p_0} \quad \ldots\ldots (16)$$

This second method may be applied to liquids and solids also, under the following conditions. The quantity

$$\frac{p_0}{\rho_0\,\tau_0}$$

is to be calculated as for the perfectly gaseous state, and the specific heat c must be uearly constant.

The ratio which the energy of periodical disturbances in a unit of volume bears to the centrifugal pressure may be interesting in connection with hypothetical views of the constitution of matter. It is expressed as follows:—

$$\frac{3\,(k-1)}{2} \quad \ldots\ldots (17)$$

The following are some examples of the results of calculations by formulæ (15) and (17):

Substance.	$\frac{c'}{c}$	k	$\frac{3}{2}(k-1)$
Atmospheric Air	1·408	1·634	0·951
Nitrogen	1·409	1·630	0·945
Oxygen	1·400	1·667	1·000
Hydrogen	1·413	1·614	0·921
Steam Gas	1·297	2·242	1·863

11. General Equation of Thermodynamics.—In the Paper of 1849–50, pages 158–164, the general equation of thermodynamics (equation 6 of that paper, p. 161) is deduced from the hypothesis of molecular vortices, on the supposition of a special form and arrangement of the vortices. In a subsequent paper, "On the Centrifugal Theory of Elasticity," read to the Royal Society of Ediuburgh in December, 1851 (Transactions, vol. xx. pp. 433–36), the same general equation (being equation 25 of the latter paper, p. 436) is deduced from the hypothesis of molecular vortices, without any special supposition as to the form and arrangement of the vortices, but with certain assumptions as to the laws of the elasticity of the matter which moves in them. In a Paper read to the British Association in 1865, and published in the *Philosophical Magazine* for October of that year, a further generalisation is effected; and it is shown that the general equation of thermodynamics follows from the supposition that sensible heat consists in any kind of steady molecular motion within limited spaces, without any assumption either as to the figures of vortices, or as to the special properties of the matter that moves in them. The object of this section of the present paper is to show how the same general equation is deducible from the hypothesis of molecular vortices, as stated at the commencement of the paper—that is, freed from all special suppositions except that of a steady circulation, combined with periodical disturbances of speed, whose energy may bear any proportion, constant or variable, to that of the steady circulation.

The forces by which an elementary circulating stream, whether flowing with a steady or with a fluctuating speed, is kept in a given state of motion and of a definite figure and dimensions, are equivalent in their action to a tension exerted at each cross section of the stream of an amount which, at a given cross section and at a given instant, is expressed in absolute units of force by the product of the mass which flows along the stream in a second into the velocity of flow at that cross section and instant. The mean value of the tension is the product of the same mass into the mean velocity—that is, into the velocity of steady circulation. Hence the mean centrifugal tension, as this force may be called, is proportional to the square of the velocity of steady circulation, and therefore to the absolute temperature; and the work done by the forces to which the virtual tension is equivalent, during a change of the figure and dimensions of all the elementary circulating streams in a given body, may therefore be expressed by multiplying the absolute temperature by the change in the value of a function, to be afterwards determined, of the dimensions, figure, and temperature. If to that function be added a function which is the integral of the increment of the energy of steady circulation divided by the absolute temperature, the sum is what I have elsewhere called the thermodynamic function. Let it be denoted by ϕ, and let $d\,Q$ denote the quantity of energy which must be communicated to the body in order to produce the increment $d\,.\,\phi$ in the thermodynamic function at the mean absolute temperature τ; then we have

$$d\,Q = \tau\,d\,.\,\phi\,; \quad \ldots\ldots (18)$$

and this, when the proper value has been assigned to the theremodynamic function, is the general equation of thermodynamics. The process of finding the value of the thermodynamic function is well known, but a summary of it will be given here for the sake of completeness:—

Let dx, dy, dz, &c., denote changes in the dimensions of unity of mass of the body, of the nature of strain, such as dilatations and distortions; and let X, Y, Z, &c., denote the forces, of the nature of elastic stress, which the body exerts in the respective directions of such changes, so that while the thermodynamic function undergoes the change $d\,\phi$ the exteroal work done by unity of mass of the body is

$$X dx + Y dy + Z dz + \&c.$$

Then, by the principle of the conservation of energy, it is necessary that the following expression should be a complete differential,

$$\tau d\phi - X dx - \&c.\,;$$

whence it follows that thermodynamic function ϕ is the integral of the following set of partial differential equations,

$$\frac{d\phi}{dx} = \frac{dX}{d\tau}\,;\ \frac{d\phi}{dy} = \frac{dY}{d\tau}\,;\ \frac{d\phi}{dz} = \frac{dZ}{d\tau},\ \&c.\,;$$

that is to say, the thermodyuamic function has the following value,

$$\phi = \psi(\tau) + \int \frac{dX}{d\tau}\,dx + \int \frac{dY}{d\tau}\,dy + \&c.,$$

in which all the integral parts are taken at constant temperature.

For a perfect gas at constant volume we have $d\,Q = J\,c\,d\tau$, in which $J\,c$ is the dynamical value of the specific heat of the gas at constant volume; and consequently $\psi(\tau) = J\,c$ hyp. log τ; and the same is the value for any substance which, at the temperature τ is capable of approaching indefinitely near to the perfectly gaseous condition. There is some reason for believing that all substances may have that property; but to provide for the possibility, pointed out by Clausius (Poggendorff's "Annalen," vol. xcvi., p. 73), of the existence of substances which at certain temperatures are incapable of approaching indefinitely near to the perfectly gaseous condition, we may make (as that author does)

$$\psi(\tau) = J\,c \text{ hyp. log. } \tau - \chi(\tau),$$

where $\chi(\tau)$ is a function of the temperature, which becomes $= 0$ at all temperatures at which an indefinitely close approximation to the perfectly gaseous states is possible—thus giving for the complete value of the thermodynamic function,

$$\phi = J\,c \text{ hyp. log } \tau + \chi\tau + \int \frac{dX}{d\tau}\,dx + \int \frac{dY}{d\tau}\,dy + \&c. \quad \ldots\ldots (19)$$

That expression may be abbreviated as follows:—Let U be the potential energy of the elastic stress of unity of mass of the body at constant temperature; then

$$\phi = J\,c \text{ hyp. log } \tau + \chi(\tau) + \frac{dU}{d\tau}\,; \quad \ldots\ldots (20)$$

and the corresponding form of the general equation of thermodynamics is as follows:—

$$dQ = \left\{J\,c + \tau\chi^1(\tau)\right\} d\tau + \tau d\,.\,\frac{dU}{d\tau}. \quad \ldots\ldots (21)$$

12. Conclusion.—In conclusion, then, it appears that the special suppositions, as to matters of detail, introduced into the hypothesis of molecular vortices in the paper of 1849-50 are not essential to the deduction from that hypothesis of the principles of thermodynamics, but that such matters of detail may be left open to be determined by future investigations.

PATENT LAW.

The Bovill Litigation.

(*Continued from page* 128.)

Bovill *v.* Cowan was argued before the Lord Chancellor, Lord Cairns, in June, 1868. His Lordship, on the 15th July, read the following judgment:—

"The Lord Chancellor: This is an appeal from a decree of the Master of the Rolls, dated the 30th July, 1867, by which his Lordship restrained, in the usual way, the defendants from infringing the patent of the plaintiff, and directed an account and inquiry, on the footing of an infringement.

"The patent relates to the manufacture of wheat and grain into meal and flour. It is dated in 1849, and prolonged for a term of five years in 1863; and it has during its existence been the subject of much and complicated litigation. The details of the various stages and forms of this litigation were, in the argument before me, elaborately commented on; but I prefer, in the first place, to endeavour to ascertain from the specification itself, read with the light derived from a consideration of the manufacture at the time, what is the precise nature of the invention claimed by the plaintiff. When this is done all questions as to the novelty of the invention, and as to the infringement of it by the defendants, will, in my opinion, be easily answered.

"Originally mill-stones were arranged either without any case or covering, or with a case or covering so constructed as to offer no obstacle to external air communicating freely round every part of the mill-stones, without any current or draught of air being produced down the eye or centre of the upper stone. Mill-stones worked in this way may be said to be worked without wind.

"When the mill-stones came to be enclosed in a case, the eye of the upper or running mill-stone being left open, and a further enclosure carried over the shoulder of the running stone excluding the external air in that direction, the centrifugal action of the running stone serrated on its face with grooves or furrows, produced a strong suction, or down draught of air through the eye of the stone, the result of which was that there passed to the outer edge, or periphery of the stones, along with the meal, a large quantity of air—the accumulations of which lodged in a warm and moist state round the outer edge of the stones, interfering with the free delivery of the meal and also causing it to be delivered in a heated and clammy condition.

"In 1846 the plaintiff took out a patent for a process in which the eye of the running stone was closed, and a blast of air introduced above the pressure of the atmosphere, at or near the centre of the stone. The object of this was to ventilate the stones and to drive out by means of the pressure of the air, the meal from between the grinding surfaces. It is obvious that one result of this superadded blast would be to increase the accumulation of air round the stones in the mill case.

"In the same year, 1846, one Newton took out a patent for a process by which he enclosed the stones, cutting them off from any connection with the external air, and making the case air-tight, except as to air entering the eye along with the grain. He then produced in the case a vacuum or exhaust, delivering the meal by the air-pump or exhausting machine, mixed with a great volume of air.

"Before 1849 there may therefore be said to have been, at different times, four modes of working. First, open working, without wind. Second, enclosed working, with an open eye, and with such blast as the fan-like action of the stones would, under such circumstances, produce. Third, working in an enclosed case, with the closed eye and with superadded blast, specially introduced near the eye. Fourth, working in an air-tight case, with an exhaust sucking in the air along with the grain, drawing it between the stones and delivering the air and meal by means of the exhaust pump.

"The first of these methods of working was, as I have said, without wind. In the other three there was the ingredient of a blast, though the blast was produced in different ways, and different degrees.

"There is no doubt now, as to what was the cause of the imperfection in these three different modes of working with the blast. The blast accumulated or condensed the air round the stones; the accumulated air was, or became hot and clammy; it prevented the free delivery of the meal, and it injured its quality; it filled the mill with stive kept in suspense, and this also affected the health of persons engaged in the work. The plaintiff says that he observed these imperfections in the working, and devised a remedy for them. He says his remedy was to apply an exhaust just adequate to suck away the accumulation, which he terms the *plenum* of hot air, carrying away with it and utilising the stive, leaving the meal to descend through the meal spout, cool and free from clamminess, and leaving the air of the mill case of the same density as the external air.

"That such an invention would, at the date of his patent have been useful is not disputed. The question is, 'Does his specification describe this invention?'

"The argument of the defendants is that the plaintiff has claimed as his invention the exhausting the plenum, when, and only when this is done in combination with a superadded blast, artificially created *ab extra* and introduced into the stones, and the defendants allege that they use their exhaust without any such superadded blast. The plaintiff contends in substance that, wherever a plenum or accumulation is created, there must have been a blast to create it; and that his patent, even if viewed as a combination, applies wherever there is a blast of any kind creating a plenum. But he contends further that the exhausting the plenum is of itself the new and important part of his invention—that his patent applies wherever there is a plenum to be exhausted—and that the reference in the specification to a blast, as combined with this exhaust, would not justify the defendants in using the exhaust alone.

"As the specification now stands it is the second part of the invention which is material. That is described thus: 'My invention consists secondly in exhausting the air from the cases of mill-stones combined with the application of a blast to the grinding surfaces.' Then, further on:—'In carrying out the second part of my invention when working mill-stones with a blast of air I introduce a pipe to the mill-stone case from a fan or other exhausting machine, so as to carry off all the warm dusty air blown through between the stones to a chamber as hereinafter described, by which the dust in the mill is avoided, and the grinding improved; and this part of my invention relates only to sucking away the plenum of dusty air forced through the stones and not to employing a sufficient exhausting power to induce a current of air between the mill-stones without a blast, this having before been practised as above mentioned.' Then in the claiming part it states: The invention consists 'secondly in exhausting the dusty air, when the same has been blown through the grinding surfaces of the mill-stones, from the stone cases or chambers receiving the meal, as herein described.'

"It is to be observed that the introductory words in these sentences spoke of exhausting the air, combined with the application of a blast to the grinding surfaces. But I cannot read these words as meaning that a blast and exhaust were to be combined for the purpose of producing by their combined action the greatest possible amount of current through the mill-stones. That would simply have been to use together, for the same end, two processes which had failed when used separately; and had failed, not from any want of power in the blast, or in the exhaust, for mechanically speaking, a blast could easily have been made as powerful as, or much more powerful than, could possibly be required. I rather view the words as indicating in general terms that the invention is to be applied to exhaust the air from the mill-stone cases where air has been introduced in too great quantities by, and is thus to be used in combination with, that is to remove the injurious effects of, a blast. The second clause of the specification commences thus: 'In carrying out the second part of my invention when working mill-stones with a blast of air.' No particular kind of blast is here mentioned, nor is any distinction made between a blast produced by some mechanical contrivance outside the stones, and a blast produced by the fan action of the stones themselves. I understand these words to mean no more than that the second part of the invention will be applicable only to mill-stones worked in such a manner as to produce in any way a current of air resulting in a plenum, or accumulation, as distinguished from mill-stones worked without producing this accumulation of wind, and that the invention will be applicable wherever a plenum or accumulation is produced. The specification then proceeds: 'I introduce a pipe to the mill-stone case from a fan or other exhausting machine, so as to carry off all the warm dusty air blown through between the stones to a chamber, as hereafter described, by which the dust in the mill is avoided and the grinding improved.' This sentence is, in fact, the key to the interpretation of this part of the invention. A blast or current of air is desirable for ventilating the stones and expediting the process of grinding. The blast may arise from mechanical contrivances outside the mill-stones and their case, or from the mere rotation of the mill-stones in an enclosed case with an open eye. But however the blast arises, it has one inconvenience, namely, that the air after being blown through between the stones accumulates and forms a plenum round the periphery, filling the mill with stive or dust, injuring the health of those engaged, losing the fine particles of the flour, and impeding the continuous delivery from the stones of the meal, and making it moist and clammy in quality. The plenum or accumulation is to be carried off by an exhaust, and the stive removed to a separate chamber, where it may be utilised. There is no doubt in this the combination of blast and exhaust, not because the combination of blast and exhaust go to make up the invention, but because the invention is in the nature of an operation or process applied to counteract or remove the plenum, which itself must necessarily be the result of a blast or current.

"The specification then adds, by way of further explanation, a reiteration of what the invention is, and a statement of what it does not apply to:—'This part of my invention relates only to sucking away the plenum of dusty air forced through the stones.' I understand this to be in the nature of a caution to the workman that he is so to temper or moderate his exhausting power as to do no more than draw or suck away the superfluous or accumulated air. It continues:—'And not to employing a sufficient exhausting power to induce a current of air between the mill-stones without a blast, this having before been practised as before mentioned.' This I understand to be another and correlative statement that the invention does not propose, and the workman is not to set up, that kind of exhaust which, like Newton's patent of 1846, was made to play the part of a superadded blast, not taking off or sucking away the accumulation of air blown through the stones, and thus separating the warm air from the meal, but violently drawing the air and meal together, and delivering both by valves through the meal spout.

"The claim on this score at the end of the specification is in harmony with the construction which I thus place on the earlier part.

"It is unnecessary, in this view of the specification, to refer to the parts of it struck out by the disclaimer, even assuming that those parts could be used to place a construction on the parts that remain.

"There is no dispute that the mode or process of grinding which I have thus described, supplied a want in the manufacture which had long been felt. There is no dispute that an improvement in the manufacture, with most important results in an economical point of view, was thus introduced under and in consequence of the plaintiff's patent. And it is a remarkable circumstance that no skilled workman, and no scientific or other witness whatever, is produced in this case to state that he could have any difficulty whatever from the specification in understanding the process which I think it thus describes, or in adjusting, setting up, or devising machinery, old or new, for the purpose of working the process.

"This construction of the specification is, in my opinion, in accordance with that which it received from the Court of Queen's Bench in Bovill *v.* Keyworth, so long ago as the year 1857, and, since, that time, from the Master of the Rolls and Vice-Chancellor Wood; and also. so far as the construction fell to be determined at *nisi prius*, from Mr. Justice Willes and Mr. Justice Byles. And the case of Lister *v.* Leather, in the Queen's Bench and Exchequer Chamber, is a strong authority against attributing—where there is an infringement of a part of an entire process which is new and material to the whole—any technical or unbending operation to the term or description of a combination.

"I have next to turn to the question of novelty: The only objections urged in the present case on the score of want of novelty, are those made in the affidavit of Mr. Pinchbeck, a consulting engineer, who refers to three French patents of Vallod, Cartier, and Damy, published prior to 1849, by deposit in the British Museum. It is not suggested that any person, either in this country or elsewhere, was ever led, by reading any of the specifications of these French patents, to adopt a process the same as the plaintiff's, and all that Mr. Pinchbeck says of them is, that the text and drawings contain descriptions clear and sufficient for a millwright of ordinary skill to construct and carry into effect apt and proper means for exhausting the stive, without carrying away the meal, and exhausting the dusty air when the same has been blown through the grinding surfaces of the mill-stones; and also for passing the dust or stive through suitable porous fabrics. In one sense, I have no doubt this is the case; I think it very probable that a skilled workman, if informed of the injurious effect of an unremoved plenum round the millstones, and desired to remove that plenum by an exhaust which would remove it and do nothing more, might use or adjust the machinery described in these French patents in a way that would effect that end; but the real question is, do those French patents profess to set forth as their discovery the removal of the plenum in this sense; and do they describe a process designed and fitted on the face of it to attain this end? I am clearly of opinion they do not. The patent of Vallod describes a process of cooling and condensation, removing the aqueous vapour escaping from the flour, and establishing certain contrary draughts and currents. The object of Damy's patent also is to condense the vapours arising in the process of grinding. The patent of Cartier was not in substance insisted upon in the argument.

I ought to notice that a reference was also made to a French patent of Cabanes which though not published in this country was said to be a patent granted in France, for the same invention as the plaintiff's, and it was alleged that this patent having expired before the plaintiff's renewed patent of 1863, his renewed patent was void, under clause 25 of the Patent Law Amendment Act. I was of opinion that there was no evidence before me as to when the patent of Cabanes had expired. But assuming this objection to be out of the way, and assuming the construction of the section in the Patent Law Amendment Act to be as contended for by the defendants, on which latter point I do not think it necessary to express an opinion, I may say that no evidence is produced in the case to show that any one from the patent of Cabanes could discover the essential point of the invention of the plaintiff, and I cannot myself, on reading over the patent of Cabanes discover that he had in his contemplation any object or process such as, upon construction, I hold to have been the object and process described by the plaintiff.

"It remains for me to consider the question of infringement. There is on this no conflict of evidence. The defendants themselves describe their machinery in this way, 'The following is an accurate description of the machinery or apparatus for grinding and of the process of grinding which was commenced to be used and was used in our aforesaid mills, at the erection thereof,' that is to say, 'the said twelve pairs of stones were disposed or placed in a row along one side of the stone floor of our said mills. Each pair of stones was placed in a mill-stone case. Each mill-stone case had one or more pipes or tubes inserted therein and ascending therefrom into a larger trunk running horizontally under the ceiling of the said stone floor room, and this horizontal trunk was afterwards carried upwards into, and terminated in, a wooden stive or dust room, which was made as nearly as possible impervious to the air. This stive room was divided into three compartments by placing therein two vertical wooden partitions. One of these partitions descended from the ceiling nearly to the floor, but did not quite reach the floor of the room, and the other partition ascended from the floor nearly to the ceiling of the room but did not quite reach the ceiling. From this room an air trunk proceeded, on the end of which a fan was placed to exhaust the air along this air trunk, and from the aforesaid stive room, and from the cases of the mill-stones. The fan operated to induce a considerable current of air to pass between the grinding surfaces of the mill-stones. By means of such aforesaid exhaust the stive or warm dusty air was drawn off from the mill-stone cases, and the greater part thereof, while traversing the length of the aforesaid vertical pipes and horizontal air trunk and the several compartments in the aforesaid stive room, became deposited therein and the remainder was forced out by the action of the fan through the end of the continuation (beyond the fan) of the aforesaid trunk into the external atmosphere. No alterations or alteration whatever have or has ever been made in the said machinery or apparatus for grinding or process of grinding in use at our said mills from the time of the erection of such mills down to the present time.' Further on, when called upon to state the difference between their process and that of the plaintiff, the defendants say no more than this: 'We admit and say that we used first and from and ever since the completion of our said mills in the month of June, 1865, as aforesaid, and that we are using in our said mills in the thirty-fourth paragraph of the bill mentioned, but not at any other place, the artificial exhaust hereinbefore in this behalf mentioned, but not any other artificial exhaust, and we say that such aforesaid artificial exhaust is not the same as, and is not only colourably differing from the exhaust of the plenum mentioned in the plaintiff's alleged letters patent of 1849, and the specification filed by the plaintiff thereunder. And we say that the extent and manner in which the said artificial exhaust so used by us as aforesaid differs from the exhaust of the plenum mentioned in the plaintiff's alleged letters patent of 1849, and the said specification thereunder, are manifest and will appear from a comparison of such letters patent and specification with the description hereinbefore given by us of the said artificial exhaust so used by us as aforesaid, and we refer to the said letters patent and specification and description accordingly, and we cannot further or otherwise set forth such aforesaid difference.' Then as regards the existence of a blast in their working, the defendants say:—'We admit that the eye of the upper or running mill stone is kept open, and that it has heretofore been kept open when the exhaust has been used at our mills; and we admit that the air does come down through the eye of the stone in the process of grinding, and that it does escape between the grinding surfaces and at the periphery of the stones.' As to the removal of stive or dusty air, the defendants say:—'We admit that at the time hereinbefore in this behalf mentioned, we erected and built at our mills, and that we have ever since used there a stive room. We have hereinbefore fully set forth how and of what materials such room or chamber is made, and how and for what purpose the same is and has been used, and how it acts. We admit and say that it is constructed with the orifice hereinbefore in this behalf mentioned, but not with any other orifices or orifice, for the escape of the warm air, and that the warm air does in fact escape through the same. We deny that the room or chamber at our said mills is similar to that described in the plaintiff's specification. We say that it differs therefrom in the particulars, which will appear from a comparison of the description of such room hereinbefore contained, with the description of the stive room, of which a description is contained in the plaintiff's specification, and we cannot set forth the difference except by such comparison. We admit that we have caused the stive or dusty air generated in the process of grinding at our mills, or such part thereof as aforesaid to pass into the said chamber or room, and we admit that the stive or dusty air has been got rid of thereby, and that a great part of, but not all, the dust or stive has been deposited in the room or chamber. We admit that our said mills have been thereby and in fact rendered clean and healthy for the workmen.' Finally, the defendants in the 23rd paragraph of their answer make this statement: 'We admit and say that the process used by us at our mills in the bill mentioned does suffice to carry off a large portion, but not all the warm dusty air, to the chamber or stive room used by us there. We admit and say that the dust and waste is thereby avoided, and that the grinding is thereby facilitated, and we admit and say that to this extent, but not further, the manufacture is thereby improved. We admit and say that during our process of grinding a vacuum is occasioned in the mill stone cases by the action of the exhaust, and that by such exhaust the pressure of the air is removed, not merely from the periphery of the stones, but from the entire of the internal area of the mill stone cases, and save as aforesaid we deny that during our process of grinding the alleged plenum of air is as it is alleged exhausted from the mill stone cases, or that the pressure of air is as it is alleged removed from the periphery of the stones. We admit and say that by the rotation of the stones there is necessarily caused a descent of air through the eye of the running stone, and which escapes through between the grinding surfaces; but we say that this involuntary and unavoidable current of air is not a blast, and that it is not forced through between the grinding surfaces. And we say that the action of the exhaust on the mill stone cases does accelerate the flow of the aforesaid current of air; but save as herein appears we deny that the removal of this alleged impediment at the alleged point of escape or exit, does, as it is alleged, allow the air to come freely out of the stones, or as it is alleged increase considerably or otherwise the alleged fan action of the stones, or the alleged blast of air blowing as it is alleged through the grinding surfaces. We admit that the meal while our exhaust is in operation does pass through the mill stone cases and down the meal spout in the usual way, and that a cool draught or current of air does pass upwards, and does wash as it were the steamy moisture of the meal as it descends. We admit and say that our exhaust does increase the current, but not the blast, theretofore existing between the stones, and that it does in fact carry away the stive and improve the grinding. We admit and say that it is the fact that by the grinding process used by us at our mills some but not all the steamy air, which has passed but has not been blown through the stones in our mills, is drawn away and separated from the meal, and that it does leave the meal cool and dry as it issues from the meal spout, and that it is the fact that very little, if any, stive or dust escapes into our mills.' This last paragraph appears to suggest a distinction—which is little more than a play upon words—between a blast of air and what it calls an involuntary, or unavoidable, current of air. The defendants admit, that by exhausting the plenum they accelerate the flow of the currents of air, and they further admit that, while the exhaust is in operation, as the meal passes down the meal spout, a cool draught or current of air passes upwards, a result which apparently could not take place if the plenum were not exhausted. In fact, the whole of the argument against infringement of the defendants in their answer, appears to be rested upon the distinction which they seek to establish between a blast of air and a current of air, which I have already dealt with upon the construction of the specification. Mr. Pinchbeck, in his affidavit, paragraph 3, speaks thus:—'In my judgment and belief, such machinery and apparatus in the defendant's mills are not, nor is any part thereof, the same or an imitation of any of the matters or things mentioned and described in the plaintiff's said specification; but, on the contrary, their modes of action and principles are different, for I say that as there is no independent blowing machine used for the purpose of forcing air into the mill stone cases, there is not any plenum of air forced through the stones to be exhausted out of the mill stone cases, and I say that in the defendant's mill the upper mill stones rotate, and I say that in the defendant's mills the stive is not filtered or strained through porous fabrics.' That is to say, Mr. Pinchbeck suggests three matters, and only three, of difference between the process in the patent and the process of the defendants. First, that the stive is not filtered or strained through porous fabrics; second, that in the defendants' mill the upper mill stones rotate; and, third, that the defendants have no independent blowing machine used for the purpose of forcing air into the mill stone cases, and, therefore, there is not any plenum of air forced through the stones to be exhausted. The first and second of these matters have no relation whatever to the second part of the patent, which is the only part said to be infringed. And the third point of difference is founded on the theory that an independent blowing machine is a necessary ingredient in the plaintiff's patent, which, in my opinion, as I have already said, it is not.

"On the whole, I am of opinion, that the decree appealed from is right, and that this appeal should be dismissed with costs, to be taxed in the same manner as directed by the decree."

This judgment can be relied upon as an authority for several propositions which otherwise it might be difficult to maintain. It establishes that "working mill-stones without wind in the ordinary manner" indicates that the mill-stones are not enclosed in a case; that when a miller is working with the exhaust for producing a current of air through the grinding surfaces, he is using a blast; that to insist upon the distinction between a current of wind and a blast of air is little more than to play upon words; that the co-existence of a mischief and its remedy justifies a patentee in describing the remedy as an invention of a combination; that it may be doubted whether it is legitimate to ascertain the meaning of a specification as it was originally framed, in order to determine its construction as altered after disclaimer; that, whilst "a blast or current of air is desirable for ventilating the stones and expediting the process of grinding,' and the specification admits that it was old to obtain that ventilating current by exhaustion, or by blast with a running top stone, and claims the monopoly of both means with a fixed top stone, there may be a good patent for using an exhausting machine, so as to do no more than reduce the air within the mill-stone case to the same density as the external air; and that this patent is infringed if the miller uses with a running top stone a fan, so as as to induce a "considerable current of air to pass between the grinding surfaces of his mill-stones; that, while there was indisputed evidence of earlier publication of "descriptions clear and sufficient for a millwright of ordinary skill to construct and carry into effect apt and proper means for exhausting the stive without carrying away the meal, and exhausting the dusty air when the same has been blown through the grinding surfaces of the mill-stones," yet this specification, admitting prior use of exhaust so as to draw air between the grinding surfaces of mill-stones with a running top stone, and claiming the monopoly of the exhaust for the same purpose with a fixed stone, and claiming the exhaust to remove the dust occasioned by the use of a blast to ventilate the grinding surfaces of mill-stones, by stating that the invention of this last form of "applying the exhaust" relates only to sucking away the plenum of dusty air forced through the stones," supplied that information, without which the workman, though possessed of descriptions clear and sufficient for constructing and carrying into effect apt and proper means for using the exhaust with or without an applied blast in combination, must be held to be unable to apply those means successfully.

It is in this manner that one of the most distinguished of the Lord Chancellors justified the wisdom of the Legislature in giving the Court of Chancery jurisdiction to decide the question as to the validity of a patent, and his own view that the Court could properly and more conveniently exercise that jurisdiction without a jury than with one.

The evidence for the plaintiff before Lord Cairns did not include any to the effect that to exhaust the plenum (without a blast) would be useful, or that any engineer or miller could, from the instruction in the specification, accomplish that task; or, indeed, that it was possible for any one to perform a feat which is equivalent to regulating the draught in a chimney, so as to carry off all the smoke though there is no fire burning. We have quoted Mr. Bovill's own evidence, that no matter how you used the very apparatus which he names in his own specification, and was shown in Cabane's drawing, you cannot, by it, exhaust the plenum. It seems that Mr. Pinchbeck's affidavit, even as quoted by Lord Cairns, imports that he regarded Mr. Bovill's invention as something altogether different from the process which his Lordship thought to be described in the specification; and it certainly is not a more remarkable circumstance that no skilled workman, and no scientific or other witness whatever, is produced to state that he could have any difficulty whatever, from the "specification, in understanding the process which he thought it thus described, or in adjusting, setting, or devising machinery, old or new, for the purpose of working the process," than that this circumstance should be relied upon by the judge, who, in a later case, decided that the evidence of witnesses—that they considered the specification to bear quite another meaning—might not be so much as read to the Court; and that their evidence, that they could not exhaust the plenum of air forced through the stones if there was not a blast to force it through, was not such as the Court ought to act upon, since the witnesses did not venture to say there was not a plenum of air on the skirt of the stone, even through there was not a superadded blast used, the Court being of opinion that there was the plenum without the blast, and that the same knowledge which enabled a man to remove by exhaust the plenum of air forced through the stones by the blast was abundant to enable him to remove the plenum which the Court was satisfied existed in every mill-stone case.

It certainly is a surprising result of the method of the Court of Chancery that its Court of Appeal should have failed to understand the meaning of the specification; have held that in its true meaning the invention was not patentable; have been so occupied in putting upon the specification an interpretation making it differ from what it acknowledged to have been done previously, as to overlook the circumstance that this invented meaning of this claim, converted the earlier claim of being one for a process which it regarded as an admitted failure.

Indeed the method of that Court in regard to patent litigation is simply intolerable. A case is brought on for argument after months of preparation and waiting It is argued at a great expense. The Court has decided that its judges can most properly dispense with the aid of juries on the trial. It is, in all other cases, one of the principles of that, as of every other Court, that the plaintiff must establish his case by affirmative evidence before the defendant is called upon. The plaintiff's case is, that each and every of the inventions claimed in his specification is new, is useful, and is sufficiently declared as regards its nature, and described as to its means of performance in the specification, and that the defendant has been using one or more of those inventions.

It is the fact, that by the method of the Court of Chancery, the wearisome and ruinous litigation that we have been recounting has been had without there being in any single instance evidence offered by Mr. Bovill that his firstly claimed or his thirdly claimed invention was either new or useful, or sufficiently described in his specification, and in the present case of Bovill v. Cowan there was not even evidence that this, his secondly-claimed invention, was new or useful, or sufficiently described in his specification.

If it had been the good fortune of Lord Cairns to have had the assistance of a jury in this case, we cannot doubt but that the omissions and the fallacies that blemish his judgment would have been avoided.

It is not conceivable that he would have allowed the case to go to the jury unless the plaintiff had given evidence of the novelty and utility of all things claimed by the specification. Evidence of the utility of the claim for using the exhaust to ventilate the grinding surfaces when the top stone was fixed, even if he had not exposed that this was a claim for tweedledee instead of tweedledum, would certainly have deterred his Lordship from telling the jury that the exhaust and the blast were each failures.

It is not because judges are less qualified than jurors to deal with questions of fact, mechanical or otherwise, or that juries are exempt from the prejudices and misconceptions which judges may form with reference to evidence, or that we can be sure they will understand the true character of an invention better than the judge is likely to do, that we insist at every opportunity on the paramount importance of trials of patent cases by jury.

The great merit of the institution does not consist in their superior intelligence, but in this that on a new trial by jury it is inevitable that the presiding judge must either have mastered the true character of the invention or display his failure to do so, and this secures the party injured by the judge's mistake, the right to a new trial. It also secures this, that the trial shall be, even if it be the 20th trial of a patent, a perfectly independent one, the jurors being told it is their sworn duty to decide for themselves upon the evidence submitted to them, unbiased by the verdicts in the former cases. It also imposes upon the judge, the duty of seeing that all the issues, of which the onus is upon the plaintiff, are covered by affirmative evidence before the defendant is called upon. It also affords the counsel for the litigants, the opportunity of submitting to the judge during his summing up suggestions, corrective of the errors into which he may fall as to the evidence that has been given, and to challenge by bill of exceptions, his ruling on points of law. We cannot conceive means more admirably adapted for securing the proper investigation of facts than the exigencies under which a judge has to sum up the case to a jury. He must expound to the jury the nature of each invention included in the specification, and the evidence as to its novelty and utility, and he must rightly instruct the jury as to the principles of law upon which they are at liberty to conclude that what has been done by the defendant is an infringement of the patent. All this he does in the presence of the parties, and with the consciousness that his reputation is dependent upon the accuracy and clearness with which he acquits himself of the duty, and that he is being criticised, and will be reviewed by men, whose faculties are sharpened by interest and by emulation.

It secures, moreover, what we shall have occasion to see is a most important object, that if the judge on one trial fell into a misconception of the meaning of the specification, or the nature of the invention, or the weight and effect of the evidence, yet as he is not responsible for the verdict upon that evidence, he is not embarrased on a subsequent trial by any anxiety to justify, the verdict in the former trial by making the latter verdict consistent with the former.

(*To be continued.*)

ON A NEW APPARATUS FOR REDUCING CHLORIDE OF SILVER.*

By A. Leibius, Ph.D., Assayer to the Sydney Branch of the Royal Mint.

In the refinage of gold bullion by Miller's new chlorine process, the silver contained in the alloy thus treated is eliminated from the latter in the state of argentic chloride, which, by a subsequent process, is reduced to metallic silver.

This reduction has always been effected in the usual manner, viz., by placing the slabs of fused argentic chloride between plates of wrought iron or zinc, with the addition of acidulated water. Although a perfect reduction to metallic silver has always been achieved, yet it required a considerable amount of time and manipulation, since the thick slabs of fused argentic chloride were, after two or three days, only partially converted into metallic silver, and had to be re-arranged in order to expedite their complete reduction. Such manipulations, however, were not only found to be very objectionable on account of the time they required, but more so on account of the very disagreeable work which they caused to the operator. The reduced spongy silver was broken up by hand into small pieces, in order to ascertain its complete reduction, and was then boiled in acidulated water to free it from iron or zinc.

It remained, therefore, a desideratum to effect the reduction of the fused masses of argentic chloride in a manner which would, at the same time, be quicker in its execution, and also obviate the just-alluded-to manipulations.

In 1868, Messrs. De la Rue and Hugo Müller, in London, constructed a galvanic battery, one pole of which consisted of fused argentic chloride the thickness of a goose-quill, the other pole of cylinders of zinc. Adopting this principle, I have endeavoured to construct an apparatus which should fulfil the requirements before referred to.

After operating successfully with a small model which allows the reduction of about 250 ozs. of argentic chloride in one operation, I have, with slight modifications, constructed an apparatus which will reduce from 1,400 to 1,500 ozs. of argentic chloride in twenty-four hours. The apparatus and its dimensions are as follows:—

Two thick boards, 15in. long, are joined together on both ends by three strong battens, so as to form an open box without a bottom, 13in. long by 14in. wide, and 15in. high (inside measurement). The two boards forming the length of the box or frame contain seven vertical grooves, ½in. wide and ½in. deep, at intervals of 1½in. from each other. These grooves are cut down to a length of 12in., leaving 3in. of each board forming the legs of the frame.

At the termination of these grooves passes horizontally a narrow slit, ½in. deep, and along the whole length of each board, into which a strip of metallic silver, ½in. wide and the thickness of a threepenny-piece, is tightly fixed, projecting on one side of the frame about 18in. beyond each board.

The seven grooves already alluded to are for holding zinc plates, ½in. thick, 14in. long, and 12in. high, which rest on both sides on the strips of silver, which, as just described, are jammed horizontally into the sides of the two boards. A connection is thus established between the seven zinc plates and these strips of silver.

The second part of the apparatus consists of a wooden frame, cut out of a solid board 1in. thick, and supplied with two large iron handles. This frame is the same length as the box holding the zinc plates, but 3in. narrower. It contains on each side, parallel to the direction of the zinc plates, twelve slits ½in. long, which hold silver bands ½in. broad and the thickness of a threepenny-piece. These silver bands are passed through the slits in the board, so as to form on each side of it six loops, 11½in. in length and ⅞in. wide. The six loops on one side are exactly opposite to those on the other side of the board, at a distance of about 9in. They are intended to hold the slabs of argentic chloride, which are 12in. long, 10in. high, and about ¾in. thick, and are put through these loops lengthwise, projecting on each end about 1in. beyond the silver bands.

The whole frame holds, as before stated, six of these slabs of argentic chloride, which are placed between the six spaces formed by the seven zinc plates, from which latter they are about ½in. apart on each side.

The projecting horizontal strips of silver jammed into the sides of the lower frame are then connected with the ends of the silver forming the loops in which the argentic chloride is suspended, and the whole apparatus thus charged is placed in a tub filled with water. After a short time galvanic action is discernible; the liquid gets gradually warmer, and a strong galvanic current is observed. After about twenty-four hours the action has nearly ceased, and the whole argentic chloride is found to be completely reduced to metallic silver, which retains in the silver loops the same shape, and, outwardly, also nearly the same appearance as when first introduced as argentic chloride. The latter contains always more or less chloride of copper, eliminated together with the silver during the operation of refinage by chlorine, which is reduced together with the chloride of silver; in fact, this soluble chloride of copper helps to act as an exciting liquor for the battery. In the first experiments, a weak solution of salt (chloride of sodium) was used as exciting liquor; but it was found that this could be dispensed with, and only common water used. The action, however, is in this case a little retarded, and does not become powerful until about two hours after the battery is set. By using a part of the resulting liquor from a previous reduction of argentic chloride, and which contains chloride of zinc, it has been found that the galvanic action sets in very rapidly, and accelerates thereby the completion of the reduction.

No acid is used, and therefore the amount of zinc used in each reduction has invariably been found to be almost the theoretical quantity required to combine the chlorine of the argentic chloride treated with the metallic zinc, in order to form chloride of zinc.

The quantity of metallic zinc thus used was always from 24 to 25 per cent. of the weight of the argentic chloride reduced.

The reduced silver is boiled out in acidulated water, in order to remove the basic and oxy-chlorides, and finally in pure water, while still suspended in the silver loops. As soon as it is taken off the last boiling, it is immediately ready for the melting pot, since the heat from the boiling water dries the porous mass of silver sufficiently to allow of its immediate melting. The seven zinc plates, when first used, weigh about 140lbs. avoirdupois; the six slabs of argentic chloride, of the dimensions already given, weigh about 1,400ozs. troy.

The zinc plates are used over again, until too thin for that purpose, when they are re-melted, and cast into new plates. It has been found that the quantity of zinc used is little, if at all, increased by prolonging the time of connection with the silver plates after the reduction is completed; the whole apparatus, when once set in operation, can therefore be left to itself until it is found convenient to melt the reduced silver.

While this apparatus reduces the argentic chloride much quicker than if the latter is simply placed in contact with zinc or iron plates, it obviates any handling of the argentic chloride from the time the latter has been placed in the silver loops until the reduced silver is ready for the melting pot—advantages which have been fully appreciated by those who formerly had to resort to tedious and disagreeable manipulations.

* Read before the Royal Society of Victoria.

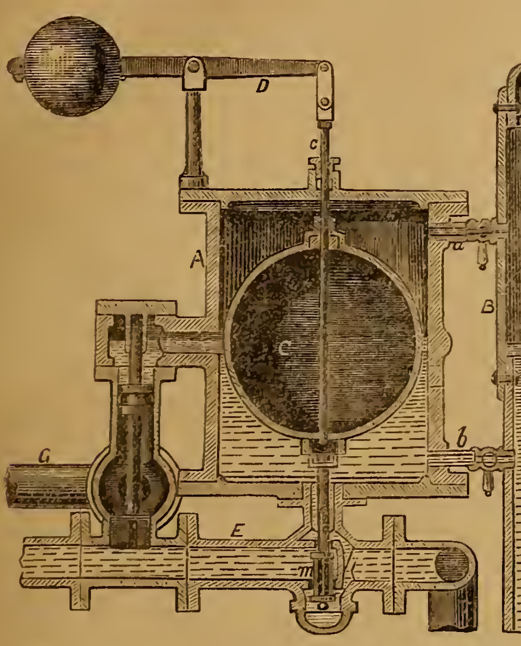
It is proposed to construct a floating dock at Auckland (New Zealand) capable of accommodating the largest ships visiting that port.

WEBSTER'S PATENT AUTOMATIC BOILER-FEEDER.

The following description of an American invention, extracted from the *American Artisan*, will, we think, be of service to some of our readers.

The improvement illustrated in the accompanying engraving embraces an automatic device for regulating the feed or supply of water to the boiler, and maintaining the same at a uniform or safe level in the boiler, even though the pump which keeps up the supply continues to operate after the boiler has been filled to the desired level.

The chamber, A, is connected at top with the steam space and at bottom with the water space, B, by pipes marked respectively *a* and *b*, in such



manner that the level of water in the chamber may correspond with that in the boiler. Within the chamber is the spherical float C, the stem, *c*, of which extends upward through the top of the chamber and connects with the loaded lever, D, this latter, by the adjustment of its weight, serving to regulate the immersion and consequent buoyancy of the float. From the bottom of the float is extended the rod, *f*, carrying the valve, *m*, arranged in the valve-box, *n*, of the feed-pipe, E. When the boiler has been filled to the required height, the water rising in the same degree within the chamber, A, lifts the float and consequently the valve, *m*, thereof, to close the outlets of the valve-box of the feed-pipe, thereby preventing the further access of water through the feed pipe to the boiler. The water thus stopped lifts by its pressure, due to the action of the feed-pump, the valve, *g*, and flows into and through the pipe, G, back to the cistern, heater, or other source of supply, whence it is again forced into the feed-pipe by the pump. It will be noticed that the stem of the valve, *g*, carries at its upper end a small piston, forced downward by the pressure of steam above it to keep the valve to its seat except when raised by the water, as just explained. When the water-level falls in the boiler, and, of course, in the chamber, A, the descent of the float lowers the valve, *m*, and the water flows into the boiler until the attainment of the requisite level again lifts the float with the results above set forth. It will thus be seen that the boiler is automatically and uniformly supplied, and all the concomitant advantages of immunity from danger, of dry steam, and economy in the generation of the steam are secured.

THE BRITISH ASSOCIATION OF GAS MANAGERS.

ADDRESS.

By Mr. MAGNUS OHREN, V.P.

Gentlemen,—You are aware that our friend Mr. Esson was at our last meeting elected president of this association, and Mr. George Anderson and myself vice-presidents. You have been informed of the severe illness which has this day deprived you of the services of a gentleman whom you did the honour to elect to a position that had he been present would have justified the high opinion you had of him. I am sure that you feel with me deep regret at the cause of his absence, and that although absent our sympathies are with him and his family, and our earnest wish is that he may be soon restored to health. When our secretary heard that Mr. Esson's medical advisers had prohibited him from taking any part in the proceedings at this meeting, a special committee was convened to the subject into consideration, as it became necessary that one of the vice-presidents should at once be elected to carry out the important duties of president, that the association should not suffer by the loss of your president's services to this office. I was proposed by my brother vice-president, Mr. George Anderson, and as the committee were unanimous in their approval of that proposition, and as the vice-presidents were elected to perform that very office, should occasion require it, I felt bound to accept the trust and carry out the duties to the best of my ability. It is under these circumstances that I preside over you this session, and it is therefore my province to deliver an address to the members of the association upon gas matters in general, but particularly to draw attention to any new subject which may have an interest to gas managers, or conduce to the interests of the companies with which all are connected.

I make the attempt with great pleasure, but, at the same time, with great diffidence, surrounded as I am by so many members of the gas fraternity whose attainments and general knowledge of gas engineering far better qualify them for the duties which it has fallen to my lot to perform; yet, however unworthily those duties may be discharged, when compared with those of the gentlemen eminent in their profession who have addressed you before—I mean the past presidents of this association—let me assure you that any failure on my part will not be from want of perseverance or attention to the duties I have undertaken.

I think the first thing I should direct your attention to is, as to the stability and prosperity of this association, for I conceive that if I can present to you a prosperous state of affairs, it will relieve your minds of all doubt as to the solid foundation on which the association stands, and on that point, I may congratulate you, as we are working with good will and harmony, not only in committee, but amongst the members generally, and the number of members is, consequently, steadily increasing.

Before our June meeting of last year, we had on our books 214 members of all classes, (honorary, extraordinary, and ordinary members); at that meeting we added 52 members to our number, making it 266, and you have just elected 54 new members, bringing our number up to 320. There are, I know, many members who are most anxious on this subject, the financial position and prosperity of the association, their great desire being to create a gas managers' benefit fund. Well, the committee go with them in that very laudable desire, but with all their desire to establish such a fund, they consider that the time has not quite arrived; nevertheless, there is a notice of motion on the subject by Mr. Warner, and all I can say is, that if the members think that the present strength of the association will warrant the starting of such a fund that every member of the committee will exert himself to establish it on the best possible foundation.

The subscriptions for 1867 amounted to £140, and left a balance in the hands of the treasurer of £6, odd; last year the subscriptions amounted to £210 with a balance in hand of £63; and this year, to the 30th of April, we have a balance in hand after meeting our liabilities of £135, so that we have now in this association the germ of prosperity.

Now how has this prosperity been arrived at, and how is it to be maintained? Why, by the amount of benefit members receive and impart by the interchange of opinions and ideas, and by the large amount of useful information to be gleaned at our meetings. Such being the case, you will be pleased to learn that we have no fewer than twelve papers promised for this session for reading and discussion on important subjects. The first paper on my list is on the "Setting and Working of Retorts" by Mr. Cathels, and whatever light may be thrown on this subject, to my mind, the "setting and working of retorts" is one of the greatest importance, and, I make no doubt, much good will result from Mr. Cathels' paper, and the discussion which such an important subject is sure to elicit; for, remember, low priced gas, dividends, and last, though not least, fees and salaries are produced from the retort, a residual product, so to speak, of good carbonising.

The next thing of importance after making the gas in good productive *quantity* is *quality*. Gas can be made practically free from impurities, and it is but right that the consuming public should have pure gas to burn, especially now that chemical science has shown us the way to free our gas from those impurities which thirty years ago we supplied with the gas, because we had not then the knowledge required to grapple with those difficulties. About that time with gas at 10s. per 1,000 cubic feet, I remember perfectly well when testing the gas for sulphuretted hydrogen by means of acetate of lead—the only test for sulphur known to gas engineers of that day—I often found the test of a shade which, if found in the gas of the present day, would make Dr. Letheby's hair stand on end with horror at the amount of impurity. Mind, I am giving you my experience of thirty years ago when I was a pupil of the engineer of one of the London gas companies. Chemical science has, however, made vast strides since then, and the case is very different in the present day. Gas can now be, and should be, sent out to the public free from visible sulphuretted hydrogen and ammonia, and further, no well regulated gas establishment should now send out gas of a less illuminating power than 12 standard sperm candles, burning 120 grains, when compared with 5ft. of gas burnt through the Letheby London burner, nor less than 13½ candles burnt through the gas referees or "Sugg's new London burner," and I believe the consumers have no cause to complain that this is not done. Gas managers are constantly trying new inventions to improve the purity and illuminating power of the gas, and when thoroughly sifted the members are always willing to impart the knowledge so gleaned, and there is scarcely a meeting of this association but we have a paper on purification in some of its branches, showing the proper importance that members attach to this subject. On the present occasion we have two such papers, one by Mr. Upward, of the Chartered Gas Company, on purification, and one by Mr. George Livesey, of the South Metropolitan Gas Company, on scrubbers. I trust we shall also be favoured by some remarks on purification from Mr. F. C. Hills, of Deptford, Mr. J. B. Paddon, of Hove, and Mr. J. W. Pollard, of Mincing-lane (one of our new members) with their views on the subject of which those papers treat. I must, however, particularly draw your attention to scrubbers; of all apparatus in general use upon a gas works, probably no portion is so uncertain and unsatisfactory in its operation as the ordinary coke scrubber. Care is taken, in designing this purifier, to provide scrubbing surface of proper proportion to the gas made, but the maintainance of this proportion is only a question of time, and often of very little time. Under very favourable conditions as regards the kind of coal used and the condensing apparatus through which the gas has previously passed, the scrubber may perform the duty for which it was intended, but almost always when a scrubber is opened it is found that there is just sufficient room in the centre to pass the volume of gas for the time being, all other openings being filled with deposit. Some admirable arrangements for distributing liquor are in use, but no mode of distribution of water or liquor that I know of can prevent or dislodge this deposit. Steam has been successfully used to prolong the life of the material, and save the cost of changing it; but any force the water may possess is absorbed by the upper strata of scrubbing material, and it simply finds its way to the central apertures through which the gas ascends. My brother, Mr. John Obren, the engineer-in-chief of the Rio de Janeiro Gas Company, substituted plates of iron for the trays of coke, and with good effect; and Mr. George Livesey will explain in his paper an admirable arrangement by means of thin boards placed edgeways tier above tier, which he has used at his works, and which, he says, is very effective, never gets out of order, and never wants changing. Well, so far we seem to be arriving at a point of perfection in scrubbers, but then we find we have arrived at the same time to a knowledge that the scrubber is, after all, not the friend to gas managers it was supposed to be. We know that scrubbing is very effective in taking out the ammonia from the gas, and it having been found necessary to reduce the amount of sulphur compounds contained in the gas to comply with the conditions required by the Metropolis Gas Act of 1860, that gas should not contain more than 20 grains of sulphur in every 100 cubic feet, the ingenuity of gas managers and gas chemists became taxed to devise means to this end. Amongst other experiments, the washing of the gas in the scrubbers, more particularly with ammoniacal liquor, was found to be beneficial in removing sulphur, and it was supposed that the greater the scrubbing surface the greater the amount of sulphur removed; but to the present time we have no reliable data to go upon. From careful testings of the gas for sulphur compounds, before and after entering the scrubber, to ascertain the full effect of the working of that part of the purifying apparatus, we find that the amount of sulphur in the gas varies, from day to day, in a remarkable manner, and from causes not yet ascertained.

The Board of Gas Referees have to determine a maximum for the sulphur compounds, and therefore their proceedings are of extreme importance to the London gas companies. Averages are of little use here, for the London Gas Acts of 1868-9 require that the maximum shall, under heavy penalties, be observed for each single day. The referees have not yet issued any public report on the subject, but I learn that experiments on a manufacturing scale—the only ones reliable—have been made, and are still in process, under the instructions of the referees, which unquestionably will throw much light on this difficult point. Among others, a systematic series of experiments is being made to ascertain the efficiency of each separate part of the various purifying processes adopted in gas works. My successor in office will be in a position to comment upon these experiments at the next annual meeting of the society. For myself, judging from the information given to me by the engineers conducting those experiments, I must say that the idea entertained in many quarters of trusting to increased scrubbing power as a means of lessening the amount of sulphur in the gas is wholly contradicted by the result of those experiments, so far as they have gone. I may add, that if the referees properly and wisely discharge the important duties devolving from time to time upon them, the result cannot fail to be of much use to the science of gas manufacture; for they have, what none of us have had before, the means of instituting careful experiments upon an uniform plan in each of the large gas works under their supervision, and thereby combining and bringing to a focus the knowledge of the able engineers of the companies, and sifting out the truth in a practical and reliable manner.

I cannot quit this subject without calling your attention to a new apparatus which the gas referees have devised for the testing of gas for sulphur compounds other than sulphuretted hydrogen. I have obtained from Mr. Sugg a specimen of this apparatus. The main difference between it and the Letheby apparatus is two-fold; firstly, instead of a large empty cylinder, the referees use a small upright cylinder filled with glass balls, a sort of scrubber, in fact; secondly, a careful adjustment has been made in order to ensure a good draught—the bottom of the Letheby apparatus is left open, and also the area of the lower end of the "trumpet tube" is considerably larger than that of the upper end; accordingly the instrument, besides requiring to be carefully guarded against side draughts, is liable to this drawback, that the external air, although drawn up by the heat to the height of the burner, cannot all pass upwards through the narrow orifice above, and consequently is liable to regurgitate and escape again at the lower end; in the referee's instrument this is prevented by covering the lower end of the trumpet tube, and narrowing the admission of air in such a way as to improve the draught, which at the same time protects the lower end of the instrument from the action of external currents. From experiments made with the two instruments, I find that the amount of sulphur obtained from the referee's test is as 30 grains against 24 grains obtained from the Letheby apparatus. I need hardly say that the adoption of this more efficient test for the sulphur compounds must, in justice to the gas companies, be properly taken into account by the referees before they fix the maximum of sulphur to be allowed in the gas companies placed under their supervision by the recent Acts of Parliament.

The next paper sent to the Committee is by Mr. Summerville, of Dublin, who will give his additional experience of the working of Best and Holden's iron stoker. I have seen the one at Dublin at work, and I would draw the attention of gas managers to the subject, more especially managers of foreign works. In places where labour is scarce, and consequently expensive, and particularly in hot climates, an iron stoker, simple in its working arrangements and managements, would be of great advantage. From what I have seen of Best and Holden's iron stoker, I have no doubt that it is very costly, and a large number of retorts must be worked to make it remunerative to the company, and then, bear in mind, the retorts are built to suit it, and not it to suit the retorts, so that it would not do for general use; but let the iron stoker be found to be useful and remunerative, and it will be constructed to suit beds of retorts as at present built. We have only to direct the attention of engineers to the want of a machine, and if it is at all likely to pay them for their trouble and expense in designing and perfecting it, they will never tire until that want is supplied. Of this fact we have evidence in the iron stoker produced by Messrs. Dunbar and Nicholson for drawing and charging single retorts. The want was felt, and to a great extent has been supplied, and I make no doubt that firm, as well as others, are now at work on plans all tending to the same end—the production of a machine perfect in its working to suit all sorts of settings.

Another example of a want being supplied is shown by the production of the "iron lamplighter." It was found that an "iron lamplighter" was wanted, as well as an "iron stoker," and the result has been the production of some ingeniously contrived apparatus, of various sorts, to effect the object required.

Mr. Price, whose apparatus was described at the last annual meeting, deserves credit for this step, which is in the right direction. His regulator (the controlling apparatus) is an ingenious adaptation of the "Cathels's district main governor," and it appears to answer equally well on a small scale as on large district mains.

Since our last meeting we have two additional "iron lamplighters"—the hydraulic lamplighter and the pneumatic lamplighter, the first designed by Mr. Hunter, an engineer, but not connected with gas works. He has produced an apparatus to be worked by hydraulic power. The peculiar feature is that by one operation the tap is opened, a match is struck, and the gas lighted. A service pipe is to be laid throughout the district to be lighted with branches to each lamp. The pipes are charged with water, and the pressure required is given and maintained from a tank placed at the required elevation. Inside each lamp post is to be placed a small cylinder, to the piston of which is attached a rod. The top of this rod is serrated, and gears into a toothed wheel attached to the plug of the lamp tap which is turned round, and opened as the plug rises. A small fusee drops from a reservoir, and is carried by a swivel plate to a piece of roughened spring, on which it is rubbed and ignited. It is then carried round past the burner, the gas is lighted, and the fusee drops to the bottom of the lantern. In the morning, when the gas is to be extinguished, the pressure of water is taken off the cylinders, and an escape tap opened, the pistons drop with the weight of the rod, and the taps are turned off. It is proposed that, as the lamps are cleaned weekly, the lamp cleaner shall supply the reservoir with a week's supply of matches.

Now, up to this point all is satisfactory. I have tried the model apparatus repeatedly, and found it to work well, the only exception to the general plan, as worked by the model, being the ignition of the matches as they occasionally fail; but this is a difficulty of little moment, as good matches can easily be procured. My great objection was, that in a hilly district the pressure of water could not be taken off the cylinders; therefore the pistons in the lamps on the side of a hill would be kept up by the pressure from the top of the hill, and as it would be out of the question to take the water out of the pipes every morning, and recharge them before night, for relighting, the lamps would continue burning. Mr. Hunter, when I discussed the matter with him, thought to get over the difficulty by weighting the rods, and varying the size of the pistons; but he took my advice not to commence in a hilly district, and he is prosecuting his operations at Southport. Another great difficulty I foresee is the freezing of the water in the pipes in winter, which, I fear, will curtail his richly deserved reward for his beautiful invention. One hint I may throw out for his consideration—the use of sea-water. It is not only at the seaside that this can be got, but as a company is forming to supply sea water in London at a cheap rate, the London gas companies can be supplied with sea-water for their iron lamplighters, unless it be superseded by the pneumatic lamplighter, the second invention mentioned, the patentees of which, Messrs. Stephenson, Bartholomew, and King, have no doubt foreseen the difficulties I have spoken of. Their "iron lamplighter" is worked with air instead of water, and from all I at present see will prove a success. There is a model working apparatus on the table, and members will not only have a chance of seeing the working of it, but have an explanation, if time will permit.

Since writing the foregoing, I have heard from Mr. Hunter. He says: "I am happy to say the apparatus works well; all through the last winter it has been entirely unaffected in its working by frost; the lamps light in rapid succession, so that the cylinders are not required to be filled all at the same moment, consequently, a small water pipe will answer the purpose."

We speak of "iron stokers" and "iron lamplighters" that may serve us by-and-bye, but in the mean time, let us all remember, that the stoker of the present day is flesh and blood, one of ourselves; do not let us forget that while we enjoy the blessing of rest from our labours on the seventh day, the stoker of the period must be at his post on that as well as other days. It gives me great pleasure to find that the subject has been taken up by Mr. Morton, of the London Gas Company, and that he will read a paper on Sunday labour. It was introduced by Mr. Livesey, of the South Metropolitan Gas Company; he commenced by giving his men a Sunday holiday once a month; it was also introduced at my company's works, some years ago, and has been continued ever since, in fact, we have lately given the men one Sunday out of three instead of every four, to carry out the desire of the directors to reduce Sunday labour as much as possible. I do not know how Mr. Livesey progresses with the Sunday question, but I trust we shall have his views thereon during the discussion on the subject. I think directors of companies will only want it made clear to them by their managers that the men can be to a great extent dispensed with on that day, to restrict Sunday labour to its lowest possible limit; the men work hard, and it is a duty of humanity, even if we take no higher ground, for persevering in carrying out this most desirable object. It is very possible that Mr. Morton will speak of the labour of the stoker; there can be no doubt about the work being hard, and in the summer time very oppressive. I once made an experiment to ascertain what amount of heat the men were exposed to, the thermometer at my office stood at 65°. At seven o'clock in the evening in the month of September, the men commenced taking off the retort lids.

At 7.15	the thermometer	rose to	70 deg.
„ 7.25	„	„	80 „
„ 7.30	„	„	88 „
„ 7.35	„	„	90 „
„ 7.40	„	„	99 „
„ 7.50	„	„	105 „

And this was the highest point.

At 7.55	it fell to	99 deg.
„ 8	„	97 „
„ 8.5	„	90 „

The men had then finished their draw and left the retort house; at 8.15, the thermometer fell to 70, and I left. The retort house is large and well ventilated. The men were in fine healthy condition, and some of them had been a long time in the employ of the company, and none of them had suffered illness from heat; nor do I remember regular stokers being incapacitated from excessive heat, except in a few cases of men green from the country on their first employment, more especially in hot weather. Circumstances, of course, alter cases; my remarks apply to the "Crystal Palace District" Gas Works. After Mr. Morton's paper is read we may get the experience of others. But I think it will be readily admitted that the stokers, as a body, are hard-working men.

(*To be continued*)

INSTITUTION OF CIVIL ENGINEERS.

ON RECENT IMPROVEMENTS IN REGENERATIVE HOT-BLAST STOVES FOR BLAST FURNACES.

By Mr. E. A. COWPER, M. Inst. C.E.

The author stated that when, in 1828, the late Mr. J. B. Neilson (M. Inst. C.E.) introduced the plan of heating the air employed as blast, by means of iron pipes placed in or near a fire, the increase of temperature was first only from 60° to 100° Fahr. Subsequently, Mr. Neilson obtained a temperature of 600° or 650°, and the pipe stoves had since been urged up to 900°, and in a few cases to 1,000°. The wear and tear, however, with such temperatures of blast were considerable; there was a great loss of heat by conduction, and the pipe stoves were as a rule worked in a leaky condition, necessitating the expenditure of engine power for blowing air uselessly.

The improvements described in the paper were based upon Mr. Siemen's regenerative furnace. Each stove of a pair consisted of a wrought-iron cylindrical casing, lined with fire-brick, and provided with a central shaft or flue, which extended to within a few feet of the brick dome forming the top. Around this shaft there were a number of compartments, or boxes, formed of brick, so placed that those in one course were not exactly coincident in position with those in the courses either above or below, though a passage was left open from the bottom to the top of the mass of brickwork. This wrought iron casing was provided with several valves, three being for the admission of cold blast of gas and of air for combustion, and two being for the exit of the hot blast and of the products of combustion. When a stove had been at work heating blast, and it was wanted to reheat it, the first thing to be done was to put another stove in operation, then to shut the hot and the cold blast valves, allowing the air in the stove to be blown out at a small valve to reduce it to atmospheric pressure. The gas, air, and chimney valves were next opened, and the gas, igniting as it entered, gave a large volume of flame right up the central shaft and over and into the regenerator, thus heating the top course of brickwork considerably, the next course rather less, and so on, the products of combustion passing away to the chimney at a temperature of about 300°. In the course of a few hours, a large amount of caloric was stored up in the bricks forming the regenerator, a good red heat penetrating nearly to the bottom, when the stove was again ready to heat the blast to a temperature of 1,400° or 1,500°. In these stoves the cost of dust catchers was avoided, and the expense of producing gas was also saved, as the gas was used from the top of the blast furnace, and the stoves could be cleaned out with the greatest facility. The construction of the regenerator in compartments or boxes, connected together vertically but not horizontally, gave the power of applying the blast with efficiency (inasmuch as the whole force of the blast was confined to the one passage that was being blown at the time), and admitted of a brush being passed up or down the boxes to remove the dust. The form and proportion of the passages had been found, after numerous experiments, to produce an excellent effect in mixing the air, thereby ensuring a rapid and perfect conduction of heat from the bricks to the air, or *vice versâ*, from the products of combustion to the bricks.

The results obtained by Messrs. Cochrane from the adoption of these stoves at Ormesby, as regarded the quality of iron, the increased make, and the saving of coke in the blast furnace, had been most satisfactory. Thus there was a saving of 4 cwt. of coke per ton of iron produced, by the use of the regenerative stoves for heating the blast, when compared with good cast-iron pipe stoves, and the saving was still more over ordinary pipe stoves. With a large furnace, producing 475 tons a week, the first cost of these stoves was somewhat less than the cost of pipe stoves, while the expense of working was less, so that the profit, taking everything into account, was estimated to amount to about £1,162 a year.

ON THE RELATIVE SAFETY OF DIFFERENT MODES OF WORKING COAL.

By Mr. GEORGE FOWLER.

It was maintained by the author, that whilst there was no possibility of freeing the workmen engaged in coal mining from accident, there was reason to hope for a considerable diminution in the proportion of those killed to the number employed. It was the purport of this communication to show that the mode of getting coal had considerable effect on the safety of the workmen. The accidents incidental to mining were classified by Her Majesty's inspectors of coal mines under five heads, as arising from explosions, from falls of roof or of coal, in shafts, from miscellaneous causes underground, and on the surface. It appeared that in the years 1866, 1867, and 1868, out of a total of 3,680 casualties, 1,091 were the result of explosions, and 1,255 of falls, or respectively 29 per cent. and 34 per cent. of the whole: the remaining 37 per cent. being attributable to the other causes, which were not influenced by the mode of working. The different methods of getting coal, which were described in detail, were the practical application of two distinct principles. One idea was to remove the coal at two operations, and this was practised in the board and pillar work of the North of England, in the bank work of Yorkshire, and in stall work of South Wales. The other idea was to remove the whole of the mineral at one operation, as exemplified in the longwall system of the Midland Counties. In the latter case, as the faces advanced, packwalls of roof rock, or bind, were built at regular intervals, and whenever a sufficient width of opening was obtained, the roof settled down, with or without fracture, upon these packs. Accidents by falls might fairly be brought to the test of figures; for although the roofs of various seams might differ much, the averages of large districts were likely to be uniform. Of a gross tonnage of 198,636,043 tons obtained by pillar work in 1866, 1867, and 1868, the casualties by falls were 814, or 231,7[illegible] tons of coal for each life. Of a gross tonnage of 22,800,000 tons extracted [illegible] the longwall plan, the casualties were 75, or 1 life for every 305,320 tons. If the latter ratio existed in pillar work, the casualties would have been reduced from 814 to 614, or a saving of 200 lives. In these calculations certain coal fields, which yielded about three-tenths of the produce of the whole kingdom, had been excluded; as in North Staffordshire, Cheshire, and Shropshire, both modes of working coal were adopted, and the same was the case in Scotland. The mortality from falls was greatest in South Staffordshire, where the lofty cavernous openings killed off 1 man for every 214,517 tons of coal raised, or an excess over the ratio of 35 per annum. There, too, the coal was obtained by both methods, but the greatest number of accidents took place in the thick seam, which was worked in pillars. The greater safety of longwall mines from falls was owing to the narrow width of the working places, to the constant change to a new roof, so that there was not time for atmospheric action, which greatly weakened the roofs of many mines, and to the small extent of open mines, which permitted a more thorough examination. It might be thought that in longwall work, the constant settlement or bending down of the roof would be attended with danger, but practically that was not the case. If a fracture occurred, it was not by the running down of a number of loose fragments, but a general settlement took place gradually, accompanied with so much noise that warning was given, when the workmen retired. The excessive mortality of some pillar districts was owing to the weak under-sized pillars, which were crushed and sank into the floor, and induced a weak jointy state of the roof. The goodness of a roof as often depended upon the way in which it was managed, as upon the character of the material of which it was composed.

With respect to explosions, the author contended that the mode of getting coal had more influence on this question than was usually allowed; and whilst fans, safety lamps, the absence of gunpowder, and all sorts of precautionary expedients were proposed, and were more or less adopted, the effect of the mode of working, perhaps the most important of all, had been lost sight of. It might be safely laid down, that that mode of working was the safest from explosions which admitted of the most perfect ventilation, which was the least subject to a local failure of ventilation, in which the discharge of gas was best regulated, in which large accumulations of gas were prevented, and in which the superintendence of the workmen could be most thorough. In an unbroken coalfield, the free hydrogen might be assumed to be distributed evenly over small areas, and each ton of coal would have a certain proportion diffused through it. If this was liberated only in the coal actually cut, and when it was cut, the amount of ventilation could be exactly regulated to the production of the mine; and the mode of work, so long as ventilation was possible at all, would be immaterial. The firedamp lying in coal seams possessed considerable mobility amongst the particles of coal, and as it was often at a pressure in excess of the atmosphere, it travelled through the coal for some distance towards a point of discharge. The rapidity with which a given area was so drained, no doubt varied in some proportion to the difference between the initial pressure of the gas and that of the atmosphere, and the amount of resistance which the gas met in permeating the coal. It also varied according as the openings were boardways, or endways of the seam. In all probability it was three or four times the greatest on the end of the coal, as the cleavage planes were to a certain extent channels for the passage of the gas. Thus, in a headway on the end of the coal, the discharge of gas was most abundant at the back of the heading; while in boardways it was most perceptible at the sides of the heading, and in such a heading a large part of the gas would probably be let off for some yards on each side. When the excess of pressure was relieved, the discharge might be supposed to vary with the changes in the barometrical pressure. It was suggested that experiments should be made in different localities, to ascertain (1) the quantity of gas given off per square yard of freshly cut surface, (2) to what extent this varied on the face or end, (3) in what ratio this discharge dimished with time of exposure, (4) to what extent barometrical changes affected the discharge of the gas, and (5) by what amount the pressure of gas increased, as measured from the exposed surface inwards to the solid seam. It was believed such experiments would show, that from 50 per cent. to 75 per cent. of the gas contained in the coal lying 10, 20, and 30 yards on each side of a boardways heading, was liberated when and after this was driven.

As the free hydrogen gas came not only from the hewn coal but also from the solid seam, it was important that the surface exposed to the air should be as small as possible. It was argued that every mode of pillar work liberated three, five, or ten times the amount of gas per ton hewn in the solid than was liberated by a system of longwall work. If, therefore, the diluting power of the air current was the same in both cases, three, five, or ten times more would be necessary in pillar mines than in longwall mines. In a mine under the author's charge, this excessive discharge of gas in pillar roads was very noticeable. Long after a headway was driven, the gas oozed out of the sides of the headway, and might be heard at a considerable distance. In the longwall faces this was not perceptible, as the gas given off there was that due merely to the coal hewn.

Again, in pillar mines from six to twenty times as much surface of coal was exposed as in longwall mines, and therefore such mines were from six to twenty times more subject to the effect of changes in the atmospherical pressure.

On inspecting the maps of mines worked by different pillar methods, and comparing them with the diagram showing a like extraction of coal by longwall, it was clear how large a proportion the gas discharged in the former must bear to that in the latter. It was frequently argued that this gas drainage was desirable, but it was submitted that before such a course could be with propriety recommended, it was necessary to show that the ventilating current would be proportional to the discharge.

The ease with which a mine could be ventilated, and the freedom from local derangement, would depend much upon the cubic contents of open mine, upon the freedom from stoppings, doors, &c., and upon the general simplicity of the arrangements. For a like extraction of coal the cubic contents of pillar mines were from ten to twenty times the amount of properly designed longwall mines, and the drawings showed clearly the relative simplicity of each. In every pillar mine the workings were driven in advance of the ventilating channels, and constant brattices were essential. It would be seen, by examining the reports, how numerous were the accidents from defective brattices.

In South Wales the working places were driven into the solid coal, and when finished had no channel left for a steady through current, and thus the chance of their harbouring firedamp was very great. In the North of England there were none of these dumb points, but the cubic contents of boards, in which there was no sensible current, was often very large. Whatever might be the difference of opinion with regard to barometrical changes in mines, it was reasonable to suppose that they would exert the least influence where the surface of coal which might exude gas was the least. The proportion which the surface exposed in pillar mines bore to that in longwall mines was from 10-20 to 1. The goaf, a longwall mine, became approximately solid as the coal was extracted over large areas, and thus permitted of a general settlement. In pillar mines the tendency was towards the formation of many small goaves, where there could be no surface settlement. These goaves thus became so many gas holders. The longwall mode of work also admitted of the nearest approximation to goaf ventilation. The only open parts were the edges, and as these were cut through with roads, a constant current could be maintained along them. It was possible, in a properly laid out longwall mine, to keep the goaf clear of gas as far back as it was open. In pillar workings there was no possibility of sending air into the goaf, and it thus became charged with gas. It was therefore submitted, that the safety of mining operations might be increased by the extension of longwall working. It was satisfactory to be able to add that, on economical grounds it was daily gaining in favour, and that simplicity, compactness, small cubic contents of open mine, small exposure of coal surface, regular gas discharge and thorough ventilation could be best attained in longwall mines.

ON COAL MINING IN DEEP WORKINGS.

By Mr. Emerson Bainbridge, Stud. Inst. C.E.

In this communication the principal conclusions arrived at were to the following effect:—

Judging from the statistics of the past few years, the production of the British coal fields could not be considered to increase annually in a constantly increasing ratio, as had been surmised, but might be estimated at an average 'output' of 105 millions of tons yearly. Estimating the coal remaining in the British Islands to a depth of 4,000ft. to be 37,300 millions of tons, this quantity of coal would supply the annual demand of 105 millions for 355 years; and, taking the limit to deep mining to be a depth from the surface of 7,000ft., the further quantity of coal estimated to be workable to this depth was 57,222 millions of tons, which would extend the supply for a further period of 535 years. The chief localities in the British Islands where coal would probably be found at greater depths than had hitherto been reached were (1) the West Coast of Ayrshire, (2) the West of Lancashire, (3) the East of Yorkshire, Derbyshire, Nottinghamshire and Staffordshire, and (4) below the seams worked at present in the South Wales basin.

Deep mining had been carried on much more extensively in Belgium than in England, there being only twelve pits of a greater depth than 1,500ft. in the latter country, as compared with sixty-eight in the former. The deepest coal mine in the world was probably that of Simon Lambert, in Belgium, which had attained the great depth of 3,489ft. The deepest coal mine in England was the Rosebridge Colliery, in Lancashire, which had reached a depth of 2,418ft., the temperature of the coal at that depth being 93·5°. The distance from the surface of the ground to the stratum of invariable temperature might be taken at 60ft., and the constant temperature at that depth at 50°. The accounts published between 1809 and 1840 of several hundred experiments, relating to the temperature of coal and metalliferous mines, showed the increase of temperature to vary from 1° for every 45ft. to 1° for every 69ft.: the distance from the surface at which the experiments were made varying from 100ft. to 1,700ft. The results of more recent experiments in England and on the Continent were irregular, and showed an increase varying from 1° for every 41ft. to 78ft., the distances from the surface being from 700ft. to 2,600ft. On comparing the experiments made at the two deepest English coal mines, viz., Rosebridge and Dukinfield, it was found that the increase of temperature due to depth was much less rapid at the latter colliery than at the former; and this difference was assumed, in a paper read recently by Mr. Hull, to be due to an amount of heat being lost at Dukinfield, owing to the heavy inclination of the strata, which was about 1 in 3, whilst at Rosebridge the coal seam was nearly level. The relation of the position of the bottom of a mine to the sea level influenced the temperature. The average increase of the temperature of three mines of a high elevation was 1° for every 71·6ft., whilst the increase for three mines at some distance below the level of the sea was 1° for every 62·3ft.

The experiments relating to the underground temperature of the air at the Rosebridge Colliery showed an increase in the temperature of the air in passing from the downcast to the upcast shaft of from 55° to 63°; the air passing through workings the temperature of which was 78°, and the normal temperature of the coal being 93·5. The experiments at Monkwearmouth showed the effect of a large volume of air in preventing a rise in temperature. At a distance of 1800 yards from the shaft, with 80,000 cubic feet of air passing per minute, the temperature was 55°; whilst at a distance of 2,600 yards from the shaft, with 10,000 cubic feet of air circulating per minute, the temperatuc was found to be 67°.

The normal temperature of the coal might be estimated, from the results of experiments at Seaham Colliery, to exist in a main air channel, which had been exposed to the air for some time, at a distance of about 13 feet from the surface of the mineral. The highest temperature at which coal mines were worked was probably in Staffordshire and at the Monkwearmouth Colliery, where the temperatures varied from 80° to 85°. At the Clifford Tin Mine in Cornwall the temperature was 120°, in which the miners could only work for twenty-five minutes consecutively, this high temperature being due to the heat of the water issuing from the rock.

It would appear, from the contradictory results of the experiments relating to the temperature of different minerals, that no rule could be laid down. It was probable, however, that the temperature of mines was affected to some extent by the varying conducting power of different minerals.

In regard to the increase of temperature with the distance from the surface, a careful comparison of all the experiments quoted, and especially of those taken at a greater depth than 2,000 feet, led to the conclusion that as far as could be judged from the experiments already made, the increase of temperature would be 1° for every 55 feet in depth, from the stratum of invariable temperature. The data afforded by the experiments were so irregular, that no law could be established, as to the ratio of increased temperature augmenting or decreasing with increased distance from the surface, though the experiments at South Hetton and at Mouillelonge, as recorded in the paper, appeared to indicate, that the rise in temperature became more rapid as the distance from the surface increased. Assuming the rate of increase in temperature to be as previously estimated, the normal temperature of a mine 7,000 feet deep would be 176°.

Of the three modes by which heat was lost by one substance and absorbed by another, viz., radiation, conduction, and convection, the only influence likely to come into action in a well ventilated mine of the depth stated would be that of convection. From the observations recorded, it would seem that, as a rule, when the temperature at the surface exceeded 66°, the temperature at the bottom of the pit was less than at the top; but when less than 66° at the top of the pit, an increased temperature was found at the bottom. The increase in the temperatue, due to the density of the air in deep mines, was estimated at 1° for every 893 feet, making the mean temperature of a pit 7,000 feet deep about 59°.

The effect of the heat emitted by workmen, candles, explosion of gunpowder, &c., was estimated not to have any appreciable influence on the temperature of the air circulating in the mine. The experiments at Seaham showed the temperature of the return air to be 0·5° lower when the mine was in full operation than when the pit was off work, and when no lamps, workmen, &c., were in the workings. An unexplained cause of high temperature had been observed at several collieries, but more particularly at Monkwearmouth, where the temperature of the air on one occasion was found to be 95°, or upwards of 10° higher than the normal temperature of the mineral. The question, as to the effect of pressure upon deep workings, was unquestionably of great importance, and necessarily very speculative. The mode of working coal, suggested for a depth of 7,000 feet, was arranged as far as possible in accordance with the principle, that the coal should removed so as to present long lines of fracture, and should be so worked as to the superincumbent weight of the strata overlying the "goaf," or space where the coal was worked out, to have all its pressure upon such "goaf," and a minimum pressure upon the coal.

The increase in temperature in an underground air channel appeared to average about 1·5° for every 500 yards.

The question of ventilating a mine 7,000 feet deep, to an extent sufficient to absorb the heat emitted by strata having a normal assumed temperature of 176°, was one of the most important in the inquiry, and the general results arrived at might thus be enumerated :—1. The temperature of the air was estimated to increase from 59° at the bottom of the downcast pit to 65° at the point where it reached the workings. 2. The length of time which would be occupied in cooling the main air-way, to such an extent that the sides of the road would have an average temperature of 62°, and the normal temperature would be found as far as 12 feet from the surface of the mineral, was calculated to be 40 days. 3. The total number of units of heat emitted by the strata per minute was found by calculation to be 45,320. 4. The volume of air introduced at a temperature of 65°, and assumed to leave the workings at a temperature of 89°, necessary to carry away this number of units of heat, was calculated to be 73,000 cubic feet per minute. 5. Then, taking the total quantity of air necessary for the ventilation of the pit to be 110,000 cubic feet per minute, the power required to produce this quantity would be 141 H.P., which represented an average temperature in the upcast pit of 90°, for the attainment of which mean temperature, a temperature of 141° was required at the bottom of the upcast pit. 6, The quantity of fuel necessary to raise the temperature of the return air from 96° to 141°, was found to be 14·04 tons every twenty-four hours.

The laws upon which the amount of power necessary to produce a certain quantity of air under every condition were stated to be as follows :— The pressure per unit of sectional area of an air-way, required to overcome the friction of the air, varied directly as the length of the air channel, as the length of the perimeter, and as the square of the velocity of the air, and inversely as the sectional area of the air-way. The action of these laws was demonstrated in the several examples given, where it was shown that the power required to overcome the resistance varied as the cube of the velocity. In drawing a comparison between furnace and mechanical ventilation, it was calculated that, at a depth of about 2,500 feet, the two modes of ventilating were equal, while below this depth the furnace became the more effective power.

In regard to raising the coal, the probable limit from which it might be drawn at one lift was estimated to be about 900 yards, below which depth one winding engine at the surface and one in the shaft would be required. An increase in the cost of sinking to great depths, and in the cost of producing the coal must necessarily be expected; but since the selling price of coal would, to a great extent, be adjusted accordingly, this could scarcely be considered as a difficulty of much consequence.

The employment of machinery in place of manual labour would probably be found very beneficial in cutting and breaking down coal in deep mines having a high temperature. Some of the coal cutting machines now at work were driven by compressed air, and the sudden decrease in temperature which compressed air underwent on exhaustion had been thought likely to be of use in reducing the temperature of the mine. In reality, however, scarcely any reduction could be anticipated, since the quantity of air exhausted bore so small a proportion to an ordinary current of air, that the effect on the temperature was only to be observed locally and to a very slight degree. Of other modes which had been proposed for facilitating the working of coal at great depths, neither that of casing the air-ways with non-conducting substances, nor the employment of the electric light, nor the use of cold water and ice, could be anticipated to have any effect worthy of note. The hygrometical experiments recorded showed that the dryness of the air was considerably increased with increased depth, especially in the return air courses; and though this usually caused a high temperature to be borne more conveniently, it could not, in the case of the heavy labour required in working coal, be calculated to confer any benefit.

Finally, it might be stated, that the question of working coal, at greater depths than had hitherto been attained, could not be considered to be one which presented difficulties of any importance, nor was it one which required immediate consideration.

The author had endeavoured to prove that coal could be worked at a depth of 7,000 feet, but it would probably be centuries before such a sinking would actually be required, and improvements in various descriptions of mining machinery, especially such as were intended to facilitate the "getting" of coal, would possibly before long render mining to such a depth, as practicable as the working of the deep mines of the present day. Commercially, as has been observed, the question would adjust itself to the requirements and expenditure of the times.

At the last business meeting of the members of this Society for the Session 1869-70, Mr. Charles B. Vignoles, F.R.S., President, in the chair, twenty-four candidates were balloted for, and declared to be duly elected, including seven members, viz.: Mr. John Bower, Dublin; Mr. George Buchanan, Westminster; Mr. William Jaavrin Du Port, late Chief Engineer of the Victoria Dock Company, Singapore; Mr. James Barry Farrell, Wexford; Mr. John Hill, Ennis; Mr. Carl Siemens, Westminster; and Mr. Robert Tyndall, Executive Engineer, P.W.D., India. Seventeen gentlemen were elected associates, viz.: Mr. John Collier, Salters' Hall; Mr. Frederick Colyer, Leman-street; Mr. Joseph Samuel Forbes, Engineer of the Trent and Mersey Navigation, Shelton; Mr. John Lawton Haddan, Engineer-in-Chief for Syria and the Lebanon; Mr. Charles Hall, Engineering Staff of the P. and O. Steam Navigation Company, Southampton; Mr. Arthur Samuel Hamand, Birmingham; Mr. Alfred Chalmers Lawford, Executive Engineer, P.W.D., India; Mr. Matthie Charles Mackinnon, Adelphi; Mr. Edward Manisty, Dundalk and Greenore Railway Pier and Harbour Works; Mr. Charles Robert Manners, Inverness; Mr. Angus Nicolson, Skipton Castle, Yorkshire; Mr. Robert Pitt, Newark Foundry, Bath; Mr. John Rotheroe, King William-street: Mr. Charles Edward Shepherd, Lieut. B.S.C., Executive Engineer, P.W.D., India; Mr. William Stroudley, Locomotive Superintendent of the London, Brighton and South Coast Railway; Mr. Henry Hay Wake, Sunderland; and Mr. Richard Harris Williams, St. Austell.

A report was brought up from the council stating that, under the provisions of Section IV. of the by-laws, the following candidates had been admitted students of the institution since the last announcement :—Messrs. H. E. R. Hogar, F. J. Odling, and H. J. Pratt.

During the Session just concluded, there have been added to the register of the institution 42 members, and 114 associates, while the council have admitted 56 students. The numbers of the several classes now on the books are 16 honorary members, 703 members, 1,002 associates, and 178 students, or a total of 1,899 of all classes, as against 1,758 at the same date last year, or an increase in the interval of upwards of 8 per cent.

INSTITUTION OF NAVAL ARCHITECTS.

ON THE SMALL FASTENINGS OF WOODEN SHIPS.

By WILLIAM POOLE KING, Esq.

The small fastenings of ships are trenails, iron bolts, and copper metal bolts. Each have their advantages and defects.

The trenail, generally an oak bar of from $1\frac{1}{4}$in. to $1\frac{1}{2}$in. in diameter, is a cheap fastening, apparently strong. It carries no galvanic influence from the outside copper on the bottom of a ship to create rust in the ironwork within, and is vulgarly considered the very stamina and constitution of a ship; still it must strike every one not blinded by routine that nothing can be more absurd than to prepare oak timbers square, and cut out all the sap from them, at the cost of about a crown per foot cubic, and then drill this expensive timber full of holes from 1¼in. to 1½in. wide, in order to drive in trenails, and thus take at least half the strength out of the timber.

About seaports, where old ships are broken up, many old timbers are met with in the fields spotted with two large holes in about every foot of their length; decay will be observed in all these holes, caused by the woody fibre being bruised by trenail driving, for bruised fibre gives nourishment to dry-rot fungus. Trenails having been squeezed in driving, become rotten and weak, cease to hold the planks to the timbers with firmness, get bent, and allow a ship to bend and yield throughout its whole frame—this is called hogging and sagging.

Iron bolts and spikes are the cheapest strength that can be put into a ship. They are the handiest fastenings that a workman can use; and a little rusting allows a very small fastening to take a very strong hold: in fact, it is everything that could be wished, did it but last without decay.

In a ship, iron bolts are always damp and always rust; rust frets away woody fibre. Iron bolts, too, always contain a portion of sulphur, which gets converted into sulphuric acid, which decomposes both the salts always found in oak, and also salt water, never absent at sea. A ring of decomposed wood surrounds every bolt; and as the salts and oxide of iron are not prejudicial to fungus growth, dry rot fungus takes possession of the ring of decomposed wood.

Iron bolts are inadmissible in the bottoms of ships sheathed with copper; the salt water acting on so large an extent of copper sends such quantities of electricity through the iron bolt that the substance of the bolt is carried away, and a vacancy, which lets in leaking water, is left in its place.

Copper bolts and cupreous metal bolts are more expensive and less strong than iron, but unlike iron bolts, instead of fretting the wood in which they are inserted, actually preserve it, for the verdigris which is formed on the copper bolt poisons the dry rot fungus. But the copper bolt has the serious disadvantage of having little hold on the wood through which it passes, and this little holdfast becomes less after the wood has shrunk with age, so that the only value of the fastening power of copper metal bolts is left in the rivetted ends of the bolt, and when this end breaks off, as it frequently does in nine or ten years, by getting crystallised, the fastening is of no value at all.

Trenails are too cheap and useful, as plugs for keeping out leaking water, to be given up in wooden ship construction; but the disadvantage of their unwieldly size, boring through and destroying everything, should be reduced as much as possible. Trenails should be always of the best materials, creosoted to prevent the introduction of dry rot, kept small in size to prevent their doing immoderate harm to the worthier parts of the ship, and driven short to obviate the destruction of timbers and floors.

It is agreed on all sides that iron bolts must never be used in the wake of copper sheathing. Indeed, to ensure the durability of the structure of a ship, iron bolts should never be driven at all, except in situations where they can be removed and replaced.

Covering iron bolts with zinc (called galvanising) does not protect the iron from rusting, as the acid of the oak surrounding the bolt soon dissolves off the zinc cover, and corrosion proceeds with all its concomitant evils.

A large quantity of copper metal fastening is now required in first-class ships. It is expensive. Let us inquire how the greatest strength, at the lowest cost, can be got from it.

The screw form, I believe, will be found the strongest and cheapest method for the use of copper metal. This form gives a secure hold, and does not injure the wood if the pitch of the screw be kept high, that is, the threads of the screw be kept far apart. I have been accustomed to use screws 7 in. long instead of trenails.

The bolt is moulded in threads three turns in an inch, cut in a ⅝-in. bolt of Prince's metal, weighing 13½ oz., and costing 9d. This screwed through a 3-in. plank, penetrates the timbers 4 in., and requires no rivet, as I have tried to start a deal end from a 4in. thick piece of oak secured in this manner, with a strain of 36 cwt. suspended, without having been able to produce the least separation of the deal from the oak. The necessity of a through fastening does not exist, as the timber can be secured to the ceiling by a similar screw to keep it exactly in place; thus, a long length of metal bolt is saved, the timber but slightly wounded, and the strength of the frame immeasurably increased.

For larger fastenings, such as those for securing timbers and floors to iron riders, I have used a thread ⅛-in. in height, placed round outside a ⅞-in. Prince's metal bolt, instead of cutting into the body of the bolt, in order to preserve its lateral strength and rigidity. The turns of the screw are three in 2 in.; a length of 14 in. weighs 3lb., and costs 2s. 6d. I found a strain of 49 cwt. was barely sufficient to tear this screw through a 3 in. deck deal end, and of course a longer length screwed into oak would require a heavier strain for its removal.

Pure copper cannot be cast into a screw form any strength, and therefore I have used Prince's metal (a mixture of 16 oz. copper, 3 oz. zinc, and ½ oz. tin). This mixture runs into every sinuosity of the casting mould, is so tough that it will bend more than double cold, and I believe will not crystallise and break when it has grown old.

APPLYING ZINC IN A FLUID STATE TO THE SURFACE OF SHIPS.

By Mr. Charles Lamport.

Mr. Chairman and gentlemen,—I am very sorry that, instead of a paper to-night, I have to present to you an apology. When at the last Session I committed myself to read a paper on a simple means of applying zinc in a fluid state to ships, my authority and authorisation was a communication which I had from abroad. The subject stood over for some time, as I was abroad engaged in other avocations, and when I came to look for that communication I found it was lost, and sufficient time has not intervened to enable me to get from my friend on the Continent a copy of what he sent me. From memory, however, I set to work to test what he stated was the fact, as to the usage in his own works, with a reference to zincing, which contained a very important difference from the usual mode practised in this country. When I came, however, to test this mode, as it occurred to my memory, I found that the experiments did not bear out results which I expected and was led to infer. I had, however, in addition, a project of my own; but as this involved a very considerable outlay, and owing to a variety of circumstances, one occuring after another, which I need not trouble you with, or detain you by detailing, these experiments were matters of utter impossibility for me to carry out in such a way as to warrant my bringing the subject authoritatively before you as an institution. I communicated with Mr. Merrifield, our honorary secretary, and at the same time asked permission to be allowed to state so much of the project as occurred to my mind, as might afford a hint to any gentleman working in the same line of investigation as myself, so as to enable him, if he should so choose, to do something in the course of the ensuing year to test the application of this principle, as I myself intend to do.

Now the difficulties of applying zinc in a fluid state to the side of a ship appear to arise from two necessary preliminaries, which must be carried out. In the first place, an iron plate, as it proceeds from the rolls, is covered over with a thin skin, which is hardened, and undergoes compression, and presents a different surface of iron, and a different composition of iron from that of the body of the plate, and this scale, or surface, or skin, or whatever term it is technically known by, presents a difficulty to the adhesion of zinc under all circumstances. Another necessary preliminary to the application of zinc is, that the iron plate shall approach very closely, if not quite attain, the temperature of the melted zinc which is to be applied. Now this, of course, any one will see, would be a difficulty on the side of a ship. But the communication which I had from abroad mentioned the use of a flux which was different entirely from that used in this country, and which enabled my friend to apply his fluid zinc in a different way from that practised in this country, namely, by pouring it over the iron to be zinced in a bath. Now the project which I intend, if circumstances are favourable, to subject to a course of experiments during the ensuing year (and as to which I have to apologise to you for not having done so at present, and for not being able to state to you the results now), is simply this. Over the sides of the ship I propose to suspend a bath, with so much of a furnace attached as will maintain the zinc in a fluid state, and, of course, maintain the temperature at a sufficient height to do so. This bath being in contact with the side of the ship to a certain extent, the plate against which it is placed will become of a temperature, I think, quite sufficient to allow of adhesion if the scale is taken off. Intermediately between the bath and the ship, I propose to have what I may term a mould, which would consist of a steel plate something like a quarter of an inch thick, rolled cold, and a very fine skin put upon it, so that the zinc should have no chance of attaching to it. Then round the edges of this there would be a thin boundary or edging of metal, of the thickness of the plate which I intend to cast on the side of the ship. Preparatory, however, to the suspension of the furnace, and the application of this mould intermediately between the furnace and the side of the ship, over a sufficient portion of the side of the ship to be zinced by each application of the movement of the furnace, I should have to remove the skin to which I have already adverted. My mode of doing that would be this: I should take a wooden mould, or frame of open framework, composed of laths of deal, or any other wood, about an inch and a half broad. This would be covered with a substance which would resist, to a certain extent, the action of a strong solution of sulphuric acid, and after the sulphuric acid had been attached to the frame, and the frame was put against the side of the ship, remaining there long enough to remove the scale. After the application of the ordinary flux by a similar frame, I then conceive that I should have the sides of the ship in a condition to receive a sufficient attachment of the plate of zinc which I propose to cast upon it. Then would come the suspension of the furnace over the ship's side, so that the metal mould, of which I have already spoken, should come exactly over, and the outside exactly accord with the wooden framework which I have just mentioned. When the steel plate had sufficient elasticity to allow screws to adjust it tightly to the side of the ship, the upper side being open, I should then propose to pour over the zinc bath the fluid metal into this mould allowing it to remain there in contact, and with a free circulation of cold between the mass of the zinc metal in the bath, and the thin film which is to form the sheet against the side of the ship. I conceive that by so doing I might, in a short time, bring up the plate to which the bath is attached to a sufficient degree of heat to conform to all the conditions necessary to perform the ordinary process of what is called galvanising, which is, more properly speaking, zincing. A zinc plate on the side of a ship has a different ratio, and different condition of construction and expansion under heat from the iron plates of a ship. Provision, therefore, should be made in some degree for buckling, imperceptibly it may be, but quite sufficient to prevent the perfect adhesion of a thick zinc plate over the whole surface of the iron plate which has to be attached. I therefore propose, supposing it were 10ft. long, with a breadth of 2ft., to depend more upon the horizontal bands for the attachment of the zinc, leaving the intermediate spaces unattached to the iron, but in close contact with it, allowing a sufficient space, if the contraction were to vary, because the heat brought to bear on the side of a ship in a tropical climate is so great as to cause a troublesome difference of expansion and that difference of expansion might be accommodated by the unattached portions between the bands. If my idea is a correct one, I should have attached to the side of a ship, by the zincing process, a zinc plate with a number of bands, which practice only could prove to be sufficiently correct, without any injury to the iron, without any expense in the structure of the ship, and which might be renewed by a very easy process, which I need not now explain, when corrosion had taken place to such an extent as to make it necessary to resheath the ship. This, gentlemen, is just an outline of my plan.

SOCIETY OF ARTS.

A NARRATIVE OF THE SUEZ CANAL WORKS.

By Daniel Adolphus Lange, Esq.

After the conquest of Egypt, in 638-40, Amrou, wishing to establish a communication between the two seas, wrote to his master, the Caliph of Omar, describing the vanquished territory as follows:—"An undulating green meadow, with ploughed fields, such is the delta of the Nile. A dusty desert, a liquid and clayey plain, a black slush, such is the Isthmus to cut through." The Caliph, however, objected to the piercing of the Isthmus, fearing that it would open out the country to the influx of foreigners.

Twelve hundred years afterwards, M. Ferdinand de Lesseps proposed to cut a direct maritime canal from Pelusium to Suez, across the dusty desert and the black swamp of Lakes Menzaleh and Ballah. I remember his speaking to me about it when I was quite a youth, more than thirty years ago. When, however, later, the project was seriously brought forward, it was declared to be impracticable. It was said, "You can never surmount the difficulties of the desert. Nothing stable can be erected on those treacherous shores, doomed by nature to sterility and desolation." In fact, so strong was that opinion, that the captain of a small craft who first received orders to proceed to Pelusium, smiled with incredulity, but resigned himself to what he thought a fool's errand, much in the same way as a slave would obey the whims of his master.

Truly, nature has indeed put every obstacle in the way of landing. Land and sea seemed to be blended, and the shallow, shelving coast rendered it impassable. There was the surf to wade through, to begin with; and if you were not dashed to pieces by it, and managed, after great exertions, to get a footing on land, you found yourself not quite on *terra firma*, but something between the two. In fact, on a narrow belt of land, not more than 150 yards wide; and behind this treacherous slip, comes a second sea as far as the eye can penetrate, with this difference, that it is calm and shallow, but at the same time absolutely unapproachable. Anyone rash enough to attempt to wade through the liquid slush would probably never have an opportunity of doing so for the second time. Such is Lake Menzaleh—such is the liquid plain spoken of by Amrou—which, for no less than twenty-eight miles, the Suez Canal had to pass, after having surmounted the difficulties of passing the strip of land already alluded to. It was under such conditions that not only a harbour but a town had to be created in a part where there was no longer any sea, and where the land had yet to be formed. That was the site on which Port Said now stands, viz., in the Bay of Pelusium, which, in fact, is the Greek word *Pelos*, meaning mud; and the Arab designation of the coast, which they call "Tineh," equally signifies mud.

As M. Lesseps could not approach this coast by sea, he attempted to do so by land. The caravan destined to explore these regions, after having for eight days wandered about the isthmus, reached a point where the travellers were prevented from going further. On the summit of the last accessible "dune" 170 camels were grouped together, carrying the baggage and provisions of the party. From this point, the plain of Pelusium could be perceived at a distance, but how to get there! Lake Menzaleh had to be reached, but, to add to the difficulty, the Nile had not risen so high as usual that year, and in consequence there remained large uncovered black patches of mud, through which no boat could pass. To arrive at the belt it was necessary to go round this immense basin, but the party were impatient to reach the end of their journey. Much time would be saved by a direct passage through it. M. de Lesseps decided, at all events, to make the attempt. The conductors of the caravan opposed it as rash, but without effect. M. de Lesseps, at the risk of being swamped every instant, waded cautiously through the basin, while the caravan were anxiously watching his movements. The attempt succeeded, and, soon after, a party of the caravan on foot were at the ruins of ancient Pelusium. The explorers then walked along the shore, both east and west, and discovered, to their great relief, that the part of the belt at Pelusium was not only firm, but gave every indication of a good and safe anchorage for vessels. After this personal examination, M. de Lesseps considered that the creation of a harbour was practicable on the spot where Port Said now stands, and soon after returned to Alexandria to make this fact known.

He then proceeded to France, but found that little heed was taken of his sanguine expectations, and scarcely any interest shown in his project—for indeed at that time nobody cared about the Suez Canal, and many Frenchmen scarcely knew where Suez was, some inquiring whether it was in Algeria or Sweden, others whether it would abbreviate the passage by the North Pole. Ludicrous as it may seem to an intelligent audience, I can assure you that such was really the fact, for amongst the many brilliant attributes of the French, I am forced to the conclusion that a knowledge of geography is not their *forte*.

The first great difficulty was to arouse public attention to the matter. Many of M. de Lesseps' best friends would scarcely listen to him in France. In a word, he could not obtain a hearing, much less make the slightest impression. Nor could it be wondered at. "The gay City of Paris," absorbed in the pursuit of amusement, was scarcely suited to become the nucleus of the greatest engineering undertaking of the age; and yet it ultimately did become so, but not until a very important phase had been gone through, and in which England played a very considerable part.

In 1857, I received a communication from M. de Lesseps, reminding me of the friendship which existed in our families, expressing a wish to come to England with reference to his idea of making a canal in Egypt. I encouraged the plan, and urged him to come over at once, feeling convinced that in co-operating with him I was assisting the cause of humanity. I entered heart and soul into his project, and abandoned every other pursuit in consequence. On M. de Lesseps' arrival in London, we lost no time in visiting all the leading towns in Great Britain, where meetings were held, viz., in London, Liverpool, Dublin, Cork, Belfast, Glasgow, Edinburgh, Leith, Dundee, Aberdeen, Hull, Manchester, Birmingham, and Bristol. Armed with the collective opinions of the commercial classes of the United Kingdom, and a most valuable record it is, M. de Lesseps returned to Paris.

It seems a very curious thing to say that the opposition in England was the cause of the success of the canal, yet so it was. It was most strenuously opposed on political grounds by the late Lord Palmerston, with whom I had the honour of having several interviews on this matter, and whom I opposed, as far as my humble powers allowed, tooth and nail. Finding my efforts in this direction were of no avail, I endeavoured to bring the matter before Parliament, and I am pleased to be able to say that 64 members of the House of Commons voted against any English interference in Turkey. Finding, however, that this made very little difference with regard to the action of the English government, I then issued a small pamphlet, called "The Suez Canal Viewed in its Political Bearing," and I think you will agree with me that the views there expressed will still bear examination.

Seeing the attention England had paid to the subject, the French, in their turn, began to talk about it. Gradually a spirit of international rivalry was sown into a commercial undertaking, a company was formed, and the capital subscribed. The works were then commenced, and I shall now endeavour to give a brief narrative of them.

At Port Said, two piers running out into the sea were constructed. The length of the western mole is 2,500 metres, equal to $1\frac{3}{4}$ mile, and the eastern 1,900 metres, equal to $1\frac{1}{4}$ mile in length. It required about 250,000 cubic metres of concrete blocks, weighing about 30 tons each, to make the two jetties. The low marsh where Port Said now stands was raised 10ft. above sea level, and occupies an area of 67 acres. The harbour has a surface of 132 acres; the excavations amounted to 4,669,943 cubic metres.

It was necessary, previously to entering upon a work of such magnitude, to prepare dwellings, storehouses, factories, forges, and a lighthouse, indeed, all the accessories indispensable for putting in motion the huge mechanical appliances intended to be used. All this was done in the newly-created town of Port Said.

Among the numerous obstacles which were encountered, none were half so formidable as effecting a channel through Lake Menzaleh, which extended 21 miles (from Port Said to Kantara). This was, indeed, the true difficulty; and while our adversaries were discussing the danger of the Red Sea, the drifting sands, and other dangers looming in the distance, our real pre-occupation was the Lake Menzaleh.

When this mud was stirred under the burning sun of Egypt, the sulphurous exhalations were almost unsupportable; but strange to say, such is the nature of the water of the lakes that it was not hurtful to the health of the men. We had the good fortune to have not much more sickness here than in the other localities. Besides, the lake fishermen are accustomed to wade up to their waist in the water, either to push their boats along or to fix their nets. They are a fine, vigorous race of men, and these we employed for the work. They had to throw up the liquid mud with their hands, so as to form a kind of dyke; and had it not been for the powerful Egyptian sun, which dried up the mud so exposed within a few hours, the task would have been hopeless, as there is no known mechanical appliance to overcome an obstacle of this sort. When something like an opening had been made, and the water began to flow in, rafts were constructed, and in these the men slept, under tents made of mats. We employed about 15,000 of these fishermen. They are supposed to be of Assyrian origin. On the west side of the lake, and while the works were progressing, an alley of sphinxes was discovered, possessing the same features and type of face as the fishermen themselves. On the shoulders of one of the sphinxes Mariette Bey deciphered the name of Pharoah, at the time of Joseph, his prime minister, and who inhabited the village of Tsane, Avaris, or Tannis.

When the men had scooped out with their hands a passage of sufficient dimensions, dredging machines were introduced, and they returned to their original occupation of fishermen. Bit by bit this trench was widened, until it reached the dimensions of 330ft. wide, and 26ft. deep. The banks on both sides are solid and firm. It was on these parts that dredgers with long shoots were used. The shoot is 220ft. long by 28ft. wide, and drawing $1\frac{1}{2}$ft. of water, with 35-horse power engines.

The dredgers, with long shoots, dispensed with the expensive mode of disposing of the *débris* of the dredgers into hopper barges, and then conveying them to sea to be emptied. These dredges have each excavated from 300,000 to 350,000 metres per annum, and some have done 3,000 cubic metres each in a day.

At the southern extremity of Lake Menzaleh, the canal quits the region of stagnant waters, and we come to Kantara, the name for bridge. This was formerly a town of importance, rivalling Pelusium, Tanis, and Rameses, and other flourishing cities on the delta of the Nile.

The caravans which conveyed to the Syrians the products of Africa, and to the Egyptians the wonders of Sidon and Tyre, and the great wealth to Jerusalem, must necessarily have passed by Kantara, then containing a population of 500,000 souls. It was destroyed in 344 by the Persians, and rebuilt by the Romans, to be again abandoned. An ancient inscription, found in the temple of Karnak, Thebes, alludes to the ancient splendour of a town in the neighbourhood of Kantara. In digging the canal, the workmen discovered nine antique lamps, of Roman origin. An old well was discovered near Kantara.

The news soon spread in Egypt and Syria that a town was being created where provisions could be had, and, above all, fresh water; and a large influx of caravans, as in ancient times, was the result; but when the water from the Nile was brought to Kantara, an immense movement followed. During the last six months of 1864:—42,929 camels, 9,350 horses, 2,489 mules, 2,835 donkeys, 3,392 head of cattle, 23,063 sheep, and 18,575 goats. Such a traffic soon gave importance to the town, which has now a population of 7,000 inhabitants.

The influx of Europeans through the canal will not alter the Asiatic and African type of Kantara, destined to become the point of transit and trade between Egypt and Syria, as in ancient times.

From Kantara the maritime canal passes through another marsh, frequently dry, called Lake Ballah, for a distance of twelve miles, to El Ferdane, and these parts were dredged with the same means as those employed across Lake Menzaleh. It is the most desolate spot possible to conceive, absolutely barren, and without the slightest vegetation. A bank of crystallised gypsum was discovered here; lime-kilns were immediately erected on the spot, and these proved of great service for the constructions at Port Said. A Frenchman, who was in charge of the lime-kilns, had a hard time of it. He lived like a hermit, with a few Arabs, pitching his tent upon any dry spot he could find, and often obliged to change quarters when any inundation occurred. He went by the name of "L'Homme au Platre," but seemed perfectly contented under these trying circumstances.

From Kantara to El Ferdane the canal passes through an undulating country, where several elevations occur, and the dredgers with long shoots, which did such good service along the Lake Menzalah, were of no use here. It required an apparatus fitted to enable the silt to be thrown over these elevations; and this necessarily led to the invention of a totally different mechanical appliance, which goes by the name of the "elevateur." The dredger excavated the canal, and deposited the contents in a floating barge placed near it. This barge has six loose compartments. When these compartments or boxes have been filled, the barge quits the dredger and goes alongside the elevator. The elevator is a kind of railed bridge, starting from the level of the water, and ascending to height of 56ft. This aerial railway is supported by two iron posts, the one resting on a barge and the other on the banks of the canal; the whole structure being joined together by solid cross beams. The full boxes are raised out of the barge by machinery, and travel along the railed bridge till the extreme end is reached, at a height of 56ft., and then discharge their contents on the banks, returning empty to be again refilled as before. Eighteen of these elevators, with 700 boxes, have been employed on the works in those parts of the canal where the banks were too elevated to allow the use of the long "couloirs," and where the distance from the sea and lakes was too great for the hopper barges to be used with advantage and economy.

The Lake Ballah terminates at El Ferdane, where the desert commences. This land is determined by a ridge of sand about 3ft. above water, a slight depression follows, the undulations become more marked, and extend along a distance of six miles. Then a sudden rise occurs, and we find ourselves in face of a mound 55ft. high and 650ft. in length. After that comes the depression, a sort of valley descending 13ft., and the Seuil d'El Guisr presents a veritable rampart of 61ft. high. It was necessary that the maritime canal should pass through this cutting, in order to allow the waters of the Mediterranean to flow in the vast depression which follows, viz., Lake Timsah. At this point all our efforts had to be concentrated; this barrier had to be removed. A trench was cut, which enabled the supply of provisions from Port Said. The encampment of El Ferdane became the "victualling entrepot." Two wells were opened, which supplied fresh water, and the shrubs of the vicinity served for fuel.

The fishermen of Lake Menzaleh having accomplished their difficult task, it now remained for the Egyptian population to surmount this second great obstacle. Before availing ourselves of the army of Fellaheens the Egyptian government had agreed to furnish for the works, it was necessary to take practical measures in advance. This operation was twofold. It was not only a question for them to dig the canal, but likewise to carry the excavations to the summit of the embankments. Wherever a steep incline rendered the labour of wheeling up a hand-barrow severe, by a simple contrivance of making the descending empty barrow assist in drawing up the loaded one, the labour was equalised and its severity negatived. In other parts, where it was necessary to remove the soil across a dry level at great distances, strong wire ropes were stretched to posts firmly fixed at the extremities of the opposite banks, and large wooden buckets filled with earth, slung to the these ropes, travelled with a rapidity regulated according to the incline, which was obtained by means of raising or lowering the ends of a lever to which the wire ropes were attached. By this contrivance, the toilsome task of removing such masses of earth by hand was considerably alleviated, and labour made to yield tenfold what it would have done without such appliances. When all was ready, and proper shelter had been prepared, the Arabs were summoned to their work, which was apportioned with great order and regularity. The men were divided into gangs, and in each division a notice in Arabic was posted up, indicating the quantity of earth to be dug, and the wages paid per cubic metre for its completion. Besides the Egyptians, the descendants of the ancient Philistines, from the countries bordering the desert of Syria, came to join in the work, and the Bedouins also found employment.

Twenty thousand men were engaged in digging the Seuil d'El Guisr; and, pending the completion of the fresh-water canal, which had to traverse 80 miles of desert, drinking water had to be procured to supply this army of men from a distance of 20 miles, a camel's day's journey. There were 2,000 camels employed, each carrying two water casks of 25 gallons of water each. The men worked cheerfully, and were treated with justice. "If you want the birds to come," said the Imaum of the mosque at El Guisr, "you must throw bread to them. If you want the men to come, you must sow justice, and our men will work for you."

The Fellaheens having completed their task, sufficient depth had been obtained for the dredgers to take their places. But here a new difficulty arose. How to dredge a channel, and then to get the earth removed out of this hollow? No less than four millions of cubic metres had to be dug out of it. The difficulty was overcome by the invention of the excavator, or dry dredger. A locomotive engine on two rails, running parallel with the canal, formed the motive power. From the locomotive descended a chain with iron buckets, which scooped up the earth as it was drawn up the slope, and then emptied into waggons. When a sufficient number were filled, these waggons, in their turn, were drawn up to the summit of the embankment, along a succession of tramways winding at sharp angles, till they reached the top. These excavations were completed on the 1st February, 1866, amid great rejoicings. We shall now leave El Guisr, and proceed to Lake Timsah.

From the summit of El Guisr to Lake Timsah the plateau still continues, undulating for about three miles, terminating abruptly like a cliff, and here we found ourselves completely in the desert.

How impressive is that dreary, shadowless desert, with its breathless silence, its awful solitude, and its solemn repose! A tacit record of a perishing world, whose race is run, of mighty kingdoms, of tumults and wars, of pestilences and plagues, of woes and death—all swept away in bygone ages, and now entombed in this mournfully silent wilderness; reminding man of the evanescence of all earthly things, with the consciousness, in that solitude more than ever felt, that he is not there alone. There are few spectacles more gorgeous than a sunset in the desert, and very unlike what is witnessed in the north of Europe. The placid sweetness of a northern day may be said to expire gradually—a flickering twilight foreshadows its consummation long before the curtains of night are drawn round the earth's bed, binding man to rest after the fatigues of the day; and then slowly the lamps of heaven are lighted up and all is still as death. Whereas in the desert there is no lingering of the sun's rays. Night, black and cloudless, seems as it were, suddenly to assume its prerogative, extinguishing the beautiful light of day, and, without forestalling its approach, dims its sunshine in the very zenith of its splendour; for in this dreary waste there is not an object to throw out a shadow which would foretell the fall of the evening. Centuries have passed over this unchanging surface, and daily the same unvarying scene continues. Here, on this hallowed ground, the wanderer's footprints leave no trace behind to mark the spot where man has been before. Slowly our camels wended their way amidst the gloom of night, their noiseless measured tread unrelieved by any sound in the distance, save the occasional barking of the desert dogs, as they came rushing in upon us, and, frightened at their own temerity, disappeared in the gloom. Nothing can describe the awful grandeur of the vault of heaven at night. The eye seems to penetrate deeper and deeper, to soar higher and higher into the transparent ether, until, humbled with its limited power of vision, it wanders again back to earth, silent and meditative. There is much inexplicable to man's reason, but nothing more overwhelmingly fascinating than to gaze upon those luminous orbs, the spangled firmament in that unfathomable dome, waiting and waiting in silent glory, one would almost imagine, for some awful summons to come forth.

It was in the midst of that dreary shadowless desert that a town had to be erected, and it was done. Ismailia now stands on the scene I have described, and the desert has been made to blossom like a rose.

I remember the 4th March, 1863, as a day somewhat memorable in the annals of Ismailia. M. de Lesseps and myself were having our early coffee, and I suggested changing the name of Timsah (by which the new town was then called) to Ismailia, out of compliment to the present ruler, Ismail, considering that Port Said was called after Said Pasha. M. de Lesseps, with that prompt action which characterises his movements, immediately called the workmen together, and, under fire of a few bottles of champagne, in the presence of an English gentleman, the Rev. E. B. Elliot, the town was rechristened Ismailia.

The filling of Lake Timsah required 80,000,000 cubic metres of water. When it was filled, and the dredgers floating at El Guisr were producing important results, the question again was how to get rid of the stuff. Special barges were constructed for that purpose, each capable of conveying 90 to 120 cubic metres, which were discharged on the borders of the lake.

Leaving Lake Timsah, the canal passes through a succession of small hillocks, and crosses the Seuil of Serapeum, rising 30ft. above the level of the sea, and continuing for a distance of seven miles. This sand barrier separates the depression of Timsah (now converted into a lake) from the ancient coast line of the Red Sea, which for centuries has been dried up.

Between Lake Timsah and Serapeum the scenery becomes most interesting. There is a hillock here, called Gebel Miriam, after the name of the sister of Moses and Aaron.

We now come to Toussoum, where the first encampment was installed. It was the centre for provisions, and all around nothing but desert. In 1860, it was already a town, and promised to become the leading city along the canal, but Ismailia has entirely eclipsed it. However, Toussoum will not be entirely forgotten. The tomb of Sheik Ennedek, held in great veneration among the Bedouins, will always bring visitors to that spot. The story goes that this was a pious Mussulman, possessing great wealth in lands and sheep. On his return from Mecca he renounced all this wealth, and became a voluntary exile on the plateau of Toussoum, that he might die alone and in peace. Many Mussulmans came to consult him, and the only payment he exacted was a stone from each person, and with the stones so obtained, he made his own tomb. It is very much visited by the Bedouins of the desert, and they bury their dead round the tomb.

The fresh-water canal in the direction of Suez has to run parallel along the maritime canal, in order to enable the conveyance of provisions by water to the different encampments. In 1862, 12,000 men were concentrated on the first section of the fresh-water canal, and a communication between Toussoum and Ismailia was effected. During the months of November and December of that year the fresh-water canal was prolonged to a distance of six miles, progressing always in advance of the excavation of the maritime canal, so that the labourers always found fresh water ready for their use—a most important matter in the desert. Three millions of cubic metres had to be dug out of these parts by manual labour, and the able contractor, M. Lavalley, hit upon a plan to bring his dredging machines over the top of those hills. It was done as follow:—As I said before, the fresh-water canal runs parallel with the maritime canal, and comes close to the Serapeum. It so happened that the natural level of this artificial derivation from the Nile, the fresh-water canal, was at the same level with the highest parts of the undulating hill of Serapeum. M. Lavelley consequently made a cutting through the intervening space, with the object of inundating these heights, and in that way introduced water, and floated the dredgers, which were ready in the fresh-water canal to come in. This contrivance did away with the necessity of a large contingent of men, and greatly expedited the work, which, with manual labour, would have been both tedious and expensive, and, in fact, presented serious difficulties. At first it was feared that the water would not have sufficient hold on the loose sand of these dunes, and that imbibition and evaporation would be too considerable for the retention of the water, and it was not without great misgiving that this bold experiment was tried. Owing in a great measure, to the circumstance of the sand here containing fine particles of calcareous matter, and the admixture with the muddy deposits from the Nile rendering the earth sufficiently impervious to retain the water, the result was that the experiment proved eminently successful.

The hollows thus filled with water from the Nile were kept isolated from the other portions of the canal until the dredgers had effected a cutting from those heights of 26ft. deep. The dams were then removed, and the water allowed to run off into the Mediterranean and Red Sea, until the sea-level had been obtained. Meanwhile the dredgers gradually sank with the receding waters, and, as a natural consequence, ended by floating on a level with the two seas. They then continued dredging until the required depth of 26ft. below sea-level had been reached. The soil dredged out was then carried away by hopper barges, and emptied into Lake Timsah. In this manner the difficult problem of dealing with the Serapeum was successfully solved, and vessels of 4,000 tons have since safely floated between these sandhills in the desert.

After Serapeum we come to the depression of the Bitter Lakes. They were separated from the Mediterranean until the necessary arrangements had been completed, by the erection of temporary weirs and sluices for the gradual admission of water.

Historians tell us that these lakes were, in ancient times, the limit of the Gulf of Suez. One thing is certain, that the shells and fossils found here are of the same species as those in the Red Sea. The conjecture the least contradicted is, that an earthquake caused the upheaving of these parts and the sea to recede to Suez, leaving the lakes and interior basin, which in process of time has evaporated.

This depression is divided into two, which form the "Bitter Lakes;" the first, descending from the heights of Serapeum, is thirty feet below sea-level, and sixteen miles in length. The second is twenty feet below sea-level, and nine miles in length. The surface soundings taken in the latter lake, showed sand and sulphate of lime with clay more or less mixed with quartz. Those in the larger lake gave the same result, with the addition of a coating of salt of considerable thickness. In both lakes isolated water-lines of high and low tides are easily discovered, also sediments of gravel, and a horizontal bank of agglomerated fossil shells about seven inches thick. These lakes were completely dried up, with the exception of the lowest portion, which still retained sufficient humidity to make the earth moist and swampy.

When the water from the Mediterranean had flowed past the Serapeum, and its progress was arrested at the "barrage" already alluded to, orders were given for the construction of sluices, in order to regulate the flow of water in the lakes, so as not to injure the banks. It was decided that a portion should be drawn from the Mediterranean, and the largest quantity of water from the Red Sea. On the 18th of March, 1869, the sluices were finished, and ready to receive the water from the Mediterranean into the Bitter Lakes. On the 18th of April in that year, in the presence of His Highness the Khedive of Egypt, the waters from the Mediterranean entered for the first time into the Bitter Lakes.

The Emperor Napoleon and her Majesty the Empress sent a telegram to M. de Lesseps, congratulating him on his success. Soon after, their Royal Highnesses the Prince and Princess of Wales visited the works of the canal, and expressed themselves gratified with all they had seen. At a given signal, and in the presence of their Royal Highnesses about twelve sluices were opened, and the sea-water rushed in. They admired the arrangements, which permitted the flow of four millions of cubic metres of water in twelve hours.

It required 1,900 millions of cubic metres of water to fill these lakes. From the 1st of March till the 1st of October it was drawn from the Mediterranean, and from the 1st of July till the 1st of October from the Red Sea: that is, during six months from the Mediterranean, and three months from the Red Sea, at the rate of 40 metres per second at the commencement, and 70 metres per second towards the finish.

At the point where the depression of the Bitter Lakes ceases, the land begins gradually to rise, until it attains the height of 16ft. above water-level, and forms in fact, the third elevation, called the Senil of Chalouf, where the very hard bank of rock was found of 15 to 23in. in thickness at the southern portion, and from six to nine feet below the level of the Red Sea. The other part of this rock was sunk 13 to 16ft. below the same level.

The Senil of Chalouf is about four miles long, and then, from Chalouf to Suez, the maritime canal flows through a vast plain of about thirteen miles in length. This was a most difficult cutting, aggravated by the presence of this rock, which had to be blasted with gunpowder. Then, again, it was not possible to apply the same principle so successful at the Serapeum, on account of the immense tract of land it would be necessary to submerge to allow dredging-machines to float. It was consequently decided to excavate this part by hand-labour. Barrows along inclined planes deposited the soil in waggons drawn up by chains fixed to a steam-engine. Pumps were placed at certain distances, to carry off the water from infiltration at the bottom of the cutting into a trench to the Bitter Lakes.

In 1869, the difficulties of the desert between Chalouf and Suez were finally overcome, 75,921,270 cubic metres having been excavated; and on the 15th August, that year, the artificial barrier which separated the Red Sea from the Bitter Lakes, then filled with water from the Mediterranean, was removed, and for the first time the two seas met. The inauguration of their union was celebrated at Suez, and, on the 28th September, M. de Lesseps steamed from sea to sea in 15 hours, all difficulties having been surmounted, and a maritime passage opened to the vessels of all nations for the benefit of mankind.

It was for this work that I abandoned all other pursuits, and devoted 13 years of unremitting labour towards its accomplishment. I remember the time when every hand was turned against the canal—when it was almost treason to advocate its cause—when scarcely a voice could be heard in its favour. All this has changed now. Success has caused popular opinion to turn. When I listened to the papers recently read at scientific institutions in praise of this great work, I often think what would I not have given for some of this a few years ago. It would have been most useful then; now that the work is finished, it comes too late.

With regard to the country through which the maritime canal is now opened it may be said that time was when Egypt was the admiration and a proverb of surrounding nations. In learning she far excelled her contemporaries. If any knowledge was sought, Egypt was the source. If important decisions perplexed the minds of kings or councils, Egypt was appealed to, and the powerful army of the Pharaohs was looked to for protection.

Will Egypt ever be a recipient of that light which can alone restore her to true greatness? May not the contact of men of northern climes, commingling with her people, one day dispel the darkness from her shores, before those pyramids have crumbled to decay, and the symbol of Caduceus shall be shorn of all save the cross as an emblem of her faith? These are questions which time only can solve.

It is well known that the Egyptians taught with subtle argument that the Divinity must be symbolised by serpents, and fallen man obeyed their teaching but too well, for the divinity they worshipped was the spirit of evil.

The sign of Caduceus, which first originated in Egypt, became in actual fact the emblem of earth's religion in that ancient time. It was formed by two serpents, representatives of the sun and moon, and their bodies intertwined depicted the solar circle and lunar crescent, and the cross the four elements.

Although that visible sign is not now acknowledged, and man no longer bows to the idol snake, nevertheless there is a worldly worship of the serpent still.

Whatever be our outward form of religion, that subtle animal is ever there, gliding imperceptibly round our motives, retarding the progress of good, causing fear and distrust, jealousy and hatred, among men and nations. It is that deadly poison which has made man lose the perception of what is due to others in the all-engrossing thought of self. It has been said that it were enough to make the very angels weep to see how we frail beings, whose life is brief as a summer's cloud, do spend it in warring with one another.

Egypt seeks no longer to be powerful or independent, nevertheless she may be great in the esteem of nations. If the hope has long since been extinguished of occupying the proud position she held before the aggrandisement of Babylon and Persia, the immediate forerunners of her decay, she may, without presumption, look forward to a time when, after resuming the gigantic work of the Ptolemys, she will open out the heart of her country to all the nations of the earth; and the present generation, from whose brow the accursed brand of the Pharaohs' rule has never been entirely obliterated, may yet live to witness a bright future dawning upon them.

It has been observed, that the first people who arrived at an advanced state in the arts of civilisation were early encouragers of agriculture and commerce, and possessed countries whose riches consisted in the produce of the soil, and that opulence and power succeed in the proportion as their condition is improved. It was this which made Egypt great and opulent. The soil of Egypt still retains all the fertility of ancient days, for those interminable unproductive wastes in the land of Goshen have assuredly not lost in richness from lying fallow since the time when "Joseph came to Pharaoh and said,—My father and my brethren, and their flocks and their herds, and all that they have, are come out of the land of Canaan; and, behold, they are in the land of Goshen;" and when Pharaoh replied, "The land of Egypt is before thee; in the best of the land make thy father and brethren to dwell: in the land of Goshen let them dwell." Nor is the husbandman's arm of the present day paralysed for work.

It is impossible to traverse that beautiful land of Goshen, abounding as far as the eye can reach with vast tracts of the richest soil in the universe, lying for centuries untilled and unproductive, without feeling that this should not be, and, in the ordinary course of events, cannot much longer be. Pelusium, at one time a bulwark against powerful aggressors, has, after a lapse of ages, become in the present day the corner-stone upon which the great work of regenerating Egypt has to be commenced; but no longer in the fashion of ancient times, when strongholds were deemed necessary, and her power extended over the vast countries between Gaza and the Euphrates.

From the shores of Pelusium (Zin), whose perfect desolation attests the awful fulfilment of the prophecy in Ezekiel, "And I will pour my fury upon Zin, the strength of Egypt,' and skirting Lake Timsah, which in the days of Moses arrested the progress of the Red Sea, thousands of human beings were congregated to remove that narrow neck of land which has, since Vasco de Gama, proved a [illegible] to her progress, by isolating her shores from the conmerce of the world, and rendering those resources barren which would have made her soil productive and her country prosperous.

Curious it is to follow out the working of man's ideas when supported by an indomitable will, and yet not wholly relying on his own strength. Not many years since, the shadows of a small group of Europeans might be seen, thoughtfully groping their way through the desert, with the light of science for their guide, marking the spots intended for future operations. Feeble and hopeless seemed these efforts at first, but the plans there matured were not destined to remain long hidden from the world, and by slow degrees other votaries, anxious to join in a work of universal utility, flocked to the scene, now no longer the undisturbed haunts of the hyæna and gazelle, but manifesting signs of human life, where man's voice ceases to be a startling sound, and where dwellings break the desolation of the scene. Fearfully at first, but reassured by the mild sway which pervades this isolated community, appeared the Bedouin of the desert, willing to lend his stalwart arms and assist in the intended work. The Fellah of Egypt, unused to seeing his labour requited, soon spread the joyful tidings, and from the shores of Syria men flocked to join in the benefits hitherto unknown in Egypt, of free and requited labour. Henceforth, the wretched homes of these people were no longer wretched, and a smile of gratitude lit up their wan faces as they gazed upon their benefactors and their improved condition. Thus, with the cement of kindness and the mallet of humanity, has the first stroke been given to the corner-stone destined to lay the foundation of Egypt's prosperity. Villages soon usurped the place of solitary dwellings, and these again have grown into populous towns; and a blank, dismal waste has thus been changed into a scene fruitful with life and hope, sown on the barren sands of Egypt.

Surely this is a work worthy the ambition of men! Of these, at least, it cannot be said—"*Eheu! vitam perdidi operose nihil agendo* (Alas! I have wasted my days in toil and have done nothing)." It is impossible to predict the advantages which may accrue from opening a maritime highway between the two hemispheres, bringing into closer union a population of 300 millions in the western and 600 millions of souls in the eastern quarter of the globe. Can this commingling of races fail to be the means of opening a path for the introduction of that light which it is the missionary's joy to spread in distant lands, brilliant with the glare of solar rays, but o'ershadowed by the darkness of unbelief? Is it not meeting him half-way in his holy work, and preparing a stupendous revolution in the traffic of the world, by changing the geographical proximity of England's great possessions in the East?

Here we behold a mighty empire in India, gradually recovering from the staggering effects of her disasters, straining every nerve to fill up a void so deeply felt in large districts in England, where a great industry is languishing from want of the accustomed supplies of cotton from foreign countries. Her lands wonderfully adapted for its cultivation, and capable of alone supplying all that England can possibly require, but unable hitherto to occupy the void left vacant, because America has the advantage of geographical proximity: and while a fratricidal war was raging in those distracted States, the peaceable scene in the Desert of Egypt presented a spectacle which was not the less striking in its solution of those difficulties because it is silent and undemonstrative. And should the cloud regather in the west, and unhappily plunge England in all the horrors of war, her merchant ships, laden with treasure from the East, and liable to piratical seizure in their circuitous voyage of ten thousand miles round the Cape, and along a sea-board too exposed to be effectually guarded, would be shielded from such dangers by a passage through the Egyptian Canal.

Aided by every contrivance which science has furnished, we have struggled to remove this barrier which Nature interposed between mighty empires, changing their relative distances, and realising results for the benefit of mankind which all the conquests in the world could never have achieved.

MANCHESTER INSTITUTION OF ENGINEERS.

ON SOME RECENT IMPROVEMENTS IN PISTONS.

By W. Lloyd Wise.

The writer is induced to submit this paper, firstly, from a strong conviction on his part that the subject is one of great importance to all who are interested in the economical working of steam engines; and, secondly, because he is enabled by the kindness of his friends, Mr. Joseph Quick, jun., C.E., and Mr. John Sampson, resident engineer of the Southwark and Vauxhall Waterworks, London, to lay before the institution some interesting facts as yet unpublished regarding the practical working of the improved pistons to which this paper has especial reference.

In pistons of many descriptions at present in extensive use, metallic or other packing is employed, and frequently in such manner as often to require adjustment by screws or other means provided for that purpose, which adjustment, besides requiring great skill and extreme care, must always be more or less uncertain, and consequently unsatisfactory, as the workman performing the operation under ordinary circumstances has no reliable indication of the extent of compression of the packing. The result often is that pistons are at first starting so tightly packed as to cause great waste of power by friction, besides occasioning rapid wear of the piston and cylinder, so that leakage quickly follows, thereby necessitating the repacking of the piston at frequent intervals, an operation which usually involves considerable expense and loss of time.

Another description of packing in very common use is the ordinary plain cast iron ring, which is likewise open to the objection that on being first put in it presses to a greater extent against the cylinder's surface than is the case after working for some little time, besides which its pressure does not vary in proportion to that of the steam upon the piston's side; consequently there is great loss by friction at first, and subsequently by leakage arising from excessive wear.

Now Messrs. Quick and Sampson obviate these serious evils by the employment of a novel and simple method, invented by them for causing the ring or rings of the piston to press constantly against the inner surface of the cylinder with a force which shall vary in proportion to the extent of variation between the pressures on the respective sides of the piston, the packing being so adjusted as to form a good, but not unnecessarily tight, joint at a minimum pressure; to force the piston ring or rings more and more tightly against the inner surface of the cylinder as the pressure upon the side of the piston increases, and to correspondingly reduce the force with which the ring or rings so presses or press against the cylinder in proportion as the pressure against the piston's side diminishes; and they attain these results without the direct action of the steam or other actuating fluid behind the packing ring. For these purposes the block or body of the piston is formed with small holes or passages, the number of which may be varied to suit the size of the piston, and these small holes or passages are fitted with corresponding small pistons properly packed and capable of moving therein when influenced by any excess of pressure at one side of the piston over that at the other side. The apparatus is so arranged that in the normal position of these small pistons—that is when there is an equal pressure on both sides of the main piston—the latter will lie or move perfectly easy within the cylinder, but that any change in pressure on the respective sides of the piston will cause the small pistons to move endwise within their respective holes or passages in the block or body of the main piston, and such movement of the small pistons will be communicated from them through the cap, top plate, or junk ring of the main piston, or through suitable L pieces or equivalent devices, to the packing ring or rings, so as to force the latter against the inner surface of the cylinder.

Fig. 1 represents a transverse section, and fig. 2 a plan (to a reduced scale) of part of a 55in. piston which has been working constantly for upwards of twelve months in a single-acting pumping engine at the Southwark and Vauxhall Waterworks at Battersea.

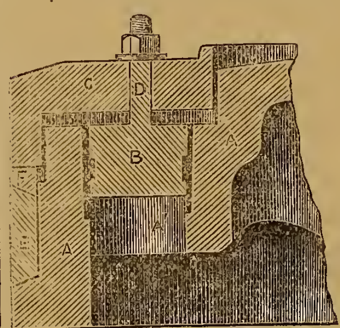


FIG. 1.

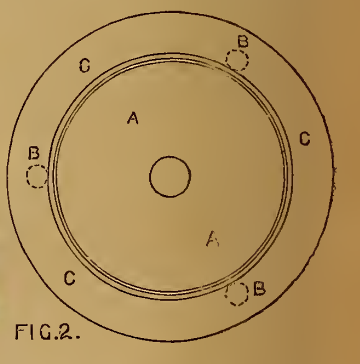


FIG. 2.

A is the block or body of the piston; it is formed with three holes or passages A^1, provided with small pistons B, 3½in. in diameter, which work therein, and are made to fit accurately by means of packing springs. The pistons B are connected to the junk ring C by small stems D, and nuts as shown; E is the packing ring, whose edges are bevelled, and F is an intermediate ring having only its lower edge bevelled.

The bevelled surfaces of the rings E and F and lower part of the packing recess are ground so as to fit one another accurately. Any excess of pressure on the upper side of the piston has the effect of causing the junk ring C to press against the intermediate ring F, thereby forcing the bevelled packing ring E against the inner surface of the cylinder by compressing it between the bevelled surfaces of the block A and intermediate ring F.

The piston previously used in this engine had a cast iron ring, backed up by india-rubber interposed between itself and the block of the piston, the india-rubber being compressed by the junk or cap ring. The result of the application of the improved piston in this case has been a reduction in friction during the down stroke equivalent to a steam pressure of 1lb. per square inch, while the relief afforded to the piston during the up-stroke has resulted in an absolute gain of 10ft. in the height to which the water is raised.

The old piston had to be looked at and repacked two or three times a year, and required a considerable quantity of grease; whereas the new one, after having run for upwards of twelve months without being inspected, was found to be in a very satisfactory condition, besides which the use of grease has been entirely discontinued.

Fig. 3 represents part of a 70in. piston applied to a direct-acting pumping engine at the Grand Junction Waterworks, Kew, working at an average steam pressure of 20lb. per square inch. This arrangement may also be applied with great advantage to double-acting condensing pumping, or marine engines. A is the block of the piston; it is formed with four holes to receive four small pistons B, each 4in. in diameter, which are connected by stems D, and nuts, to the junk ring C as shown. The block A is furthermore formed to receive L pieces G, whose ends G^1 take in recesses formed in the sides of the small pistons B. When the pressure of the steam is on the under side the small pistons B act against the ends G^1 of the L pieces, and cause their edges G^2 to describe the arc of a circle, and so to force the packing ring E against the interior of the cylinder; but when (in double-acting engines) the steam pressure is against the upper part of the piston, then the junk ring C presses against the intermediate ring F, so that the bevelled packing ring E is forced against the interior of the cylinder by being compressed between the bevelled surfaces of the block A and the intermediate ring F.

The following report, dated Feb. 12th, 1870, is from Mr. Alexander Fraser, engineer to the Grand Junction Waterworks. He says:—

"With respect to the patent piston which we have had fitted to the 70in. direct-acting engine at our Kew works, I am happy to say that it is a decided success. Since its introduction we have been able to dispense with a ton weight on the loaded plunger, showing a reduction in friction of over 5 per cent.; and whereas the former packed piston required 4lb. or 5lb. of tallow per day, the new piston requires almost none at all. There is a saving on this head of quite £30 per annum, besides other advantages due to the absence of tallow in the cylinder. I shall certainly advocate the introduction of the new piston in the other engines at our different works, as opportunities occur for removing the present pistons."

A piston of the same construction as that referred to in Mr. Fraser's report has just been supplied to the Portsmouth Waterworks Company for a double-acting engine. Fig. 4 represents to a larger scale part of one of

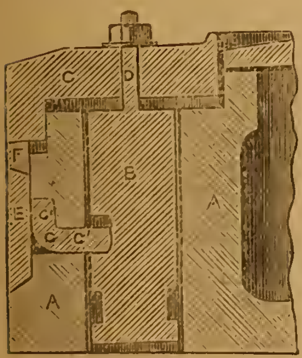


FIG. 3.

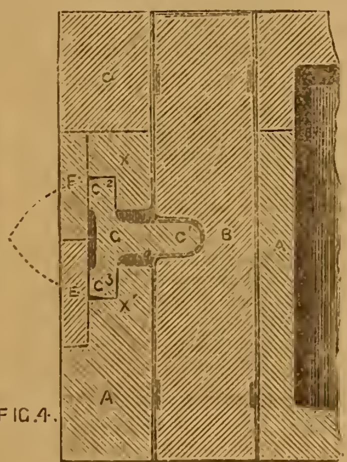


FIG. 4.

the improved pistons of 10in. in diameter as applied with very satisfactory results to high-pressure double-acting engines at the Southwark and Vauxhall Waterworks, Battersea, and elsewhere. This arrangement of piston is suitable also for locomotives and other classes of high-pressure double-acting engines. A is the block or body of the piston; it is made with three holes or passages fitted with corresponding pistons B, each 1½in. in diameter. These pistons pass through suitable holes formed for that purpose in the cap ring C, which is in this case fixed to the block or body A of the piston by means of bolts; F and E are the packing rings. They are kept pressed against the interior of the cylinder by means of the T pieces G which are fitted into the block A; the ends G^1 of these T pieces pass through holes A^1 in the block A, and are let into recesses in the sides of the small pistons B. These recesses are of sufficient size to allow for the necessary motions of the T pieces when actuated by the movement of the small pistons, and for the same reason the edges G^2 G^3 of the T pieces are slightly bevelled. It will be evident that when the pressure of the steam is on the upper side the small pistons act against the ends G^1 of the T pieces, and cause their edges G^3 to describe the arc of a circle whose centre is at X, as shown dotted, and thus to force the lower packing ring E^1 against the interior of the cylinder; and that when the pressure is on the under side the edges G^2 of the T pieces are caused in like manner to describe the arc of a circle having its centre at X^1, so as in turn to force the upper packing ring F against the interior of the cylinder to form the joint.

In a report referring to one of these pistons, Mr. Anderson, of the eminent firm of Easton, Amos, and Anderson, says:—"The patent piston has been in our foundry engine for a fortnight now, and to-day I had the cover taken off the cylinder and examined it. The engine is horizontal, and runs from 120 to 150 revolutions per minute under 50lb. steam. I had the fly-wheel scotched, and turned the steam full on the piston on the side opposite that from which the cover was removed. I found the cylinder very nicely polished, no trace of scoring anywhere, and the quantity of steam passing very insignificant considering the fact that the cylinder had run four or five years with another piston and worn oval in the middle."

At the Battersea works of the Southwark and Vauxhall Waterworks Company a piston similar to that referred to in Mr. Anderson's report has been in constant use for about nine months.

During that time it had been examined twice, and was on both occasions found to be in first-rate order. It was put in to supersede a piston with a metallic ring, kept up by metallic springs, which, however, were a source of constant trouble and expense. It may not be out of place here to remark that the duty required to be done by the engines at such establishments as the Battersea Waterworks is of a character which imperatively demands the utmost regularity of action, and therefore that any appliance which is found to satisfactorily fulfil the requirements of such a situation (as Messrs. Quick and Sampson's piston has done) must, as a natural consequence, be one upon whose actual performance of its duty the most complete reliance can be placed.

ROYAL GEOGRAPHICAL SOCIETY.

A meeting was held of this society on the 9th of May, Sir Roderick Murchison, President, in the chair, at which Mr. Consul Swinhoe read a paper on his official mission last spring to the Upper Yang-tse-Kiang, to examine the trade resources of the river. He ascended to Hankow, in the *Salamis*, with Admiral Sir Henry Keppel, and continued his voyage thence in the gunboat *Opossum*. The *Opossum* reached the town of Ichang, about 900 miles from the sea, being the first vessel that had accomplished the navigation, although it had been known since Blakiston's report that the Yang-tse was navigable to that port. Beyond Ichang the great river is contracted between walls of rock, and the current runs with great rapidity. The Chinese pilot refused to take the gunboat further, and the rest of the journey to Chung-King in Sze-Chuen was performed in a native boat, which was "tracked" through all the difficult places. Two naval surveyors (Messrs. Dawson and Palmer) accompanied Mr. Swinhoe, and after examining the rapids, they reported that steam navigation could not be carried on the Yang-tsze beyond Ichang. Mr. Swinhoe, with two delegates from the Shanghai Chamber of Commerce, reached Chung-king, and were well received there by the Chinese authorities and traders, who gave much information about the routes, products, and trade of this remote province, all of which is contained in a report by the delegates published at Shanghai. After the paper, Mr. T. T. Cooper, who had recently returned from Assam, after having in vain attempted from both sides to cross the tract of difficult country lying between China and British India, spoke of the possibility of the gorge of Ichang being made navigable by the removal of rocks that cause the obstructions, and said there was a long extent of fine navigable river beyond the gorge. In reply to questions concerning the production of opium in Sze-chuen and the prospects of its interfering with our Indian trade in this drug, he replied that the opium of Sze-Chuen was of weaker quality and so heavily taxed by Mandarins in descending the river that it could not compete in Eastern China with the opium brought from India. A second paper was read by Mr. W. A. Whyte on his journey last October from Tien-tsin to Kiachta across the Desert of Gobi. Admirals Sir William Hall, Bethune, and Collinson, Mr. George Campbell, Mr. W. Lockhart, and Mr. Robert Mitchell took part in the discussion on the two papers. At the conclusion of the meeting the President informed the members of a fact which he said would gratify both them and the public, that in consequence of an appeal which he had made to the Earl of Clarendon, Her Majesty's Government had determined to afford the means of relieving the great traveller Livingstone by sending supplies to him at Ujiji from Zanzibar.

PROPOSED RAILROAD THROUGH GREENWICH PARK.

The Admiralty report on the South-Eastern Railway Company's Bill, authorizing a line of railway passing through Greenwich Park, has been laid before the House of Commons. The Admiralty have determined to oppose the Bill. The Astronomer Royal, in a memorandum addressed to the Admiralty, states that every foreign geographical determination of distant points has for many years depended on reference to Greenwich observations, and that there is no doubt that some suspicion would attach to these observations if a railway passed through the park. As regards communication between London and Woolwich, now that the North Kent line has been constructed, the journey would, perhaps, be shortened by three minutes, but even this small gain might be neutralized by the passage through an important station like Greenwich. Communication between Greenwich and Woolwich is wanted, but it can be obtained at very small expense, and has no reference to the park. If there is real want of independent communication between the eastern part of Deptford and Woolwich it can be obtained at small expense by junction with the North Kent line. Connexion is really wanted between London and a station in East Greenwich, but the rising tramway system may possibly be so inoculated into the railway system as to give reasonable facilities. Certainly, says the Astronomer Royal, this connexion cannot justify the national dishonour, the enormous expense, and the injury to West Greenwich which would arise from carrying the line through the park. The Observatory is mainly for the promotion and advantage, not of speculative, but utilitarian astronomy, and its actual utility is not simply national, but universal. His ground of objection would be removed by power given him to control the speed of trains; but such interference would be troublesome to the Astronomer Royal and annoying to the railway company, and he anticipates that the provisions would be found to be nugatory. If effectual, they would tend still further to diminish the imagined gain of rapid transit. The Hydrographer of the Admiralty comes to the same conclusion. He remarks that the results of the trials made with a view to ascertain within what limits the vibrations caused by trains will affect the most delicate observations have been conflicting; in some instances the tremors have been felt at a distance over 3,000ft., while in others they have not been apparent at much less distances. But it is impossible to say what the effect will be at the Royal Observatory until the railway should be in operation, and the objects at stake are of so momentous a character, that the Hydrographer cannot conceive how merely pecuniary interests (and they are of a most insignificant nature) can be put in competition with them. Even if the interests of the local public make it desirable that the railroad should run through Greenwich Park, they should succumb to the grave and more than national interests involved. There is not a spot on the earth's surface where astronomical observations have been or will be made which is not more or less subservient to or associated with the Royal Observatory at Greenwich. Many foreign nations are entirely dependent on it.

NEW METHOD OF HEATING STONEWARE VESSELS, AND OF OBTAINING REGULATED HIGH TEMPERATURES.

In conducting chemical and pharmaceutical operations for manufacturing purposes, it is generally necessary to effect evaporation and distillation in stoneware vessels; but great difficulty has been hitherto experienced in obtaining a sufficiently high temperature without cracking or breaking the pan employed. The use of a naked fire inevitably causes a fracture; and a sand-bath offers too great an obstruction to the passage of the heat. With a steam-jacket, it is impossible even to raise water to the boiling-point, unless, indeed, such a pressure of steam be applied as to cause a very dangerous strain on the flanges of the vessel.

A new method of applying heat, however, has been patented by Mr. J. A. Coffey, the pharmaceutical engineer, and is now introduced by Messrs. Doulton and Watts, for working stoneware pans and stills, by which any temperature ranging from 100° to 700° F. can be safely and easily obtained.

Mr. Coffey's principal is to cause heavy paraffin-oil to circulate, first through a coil of pipes in a furnace, and then through the jackets of the pans. The oil is carefully selected for the purpose, from the heaviest of the petroleum or paraffin products. It moves by its own convection. Heated in a close coil of pipe by a coke fire, it rises into an air-tight tank, from which it passes, through pipes, to the jackets of the different vessels to be headed, returning after it has done its work, to the lowest part of the furnace-coil; a continuous circulation is thus maintained, similar to that which occurs in a hot-water apparatus for warming buildings. After leaving the tank, the oil passes through a pyrometer, by which its temperature is indicated, and, by means of dampers, &c., to the fire this can be regulated to any required point. The heating medium is turned on or off the jackets by taps, in the same manner as steam; and, as the rate of flow can be checked or augmented at will, the temperature is perfectly under the control of the operator.

In the model which has been fitted up at Messrs. Doulton and Watts's to illustrate the principle of this method of working, the pyrometer generally indicates from 600° to 700° F., while a saturated solution of chloride of calcium is maintained at the boiling-point in a shallow stoneware pan. No smell of oil is perceptible in the room; and it is stated that the same oil may be used for years, without deterioration or causing any deposit in the pipes. As contrasted with steam-heat, the inventor claims for his process a saving of 30 per cent in fuel. It is obvious that the large amount of heat necessary to convert water at 212° F. into steam at 212° is hereby economised. The stoneware used in this process is manufactured expressly by Messrs. Doulton, to ensure its being quite impervious to the oil.

H.M.S. "BRITON."

There have been lately carried out a series of trials of this vessel to which especial interest is attached on account of the novelty in the arrangement of her machinery. The engines of the *Briton*, which are the first compound engines ever supplied to the British Navy, were constructed by Messrs. J. & G. Rennie, of Blackfriars-road, London, with Mr. E. A. Cowper's steam-jacketted reservoir between the cylinders, and have obtained the greatest result in economy of coal of any engines of the British Navy, being at the rate of 1·98lb of coal consumed per indicated horse-power, or less than 2lbs, when working at full power during six continuous hours at sea; and only 1·31b per indicated horse-power per hour when driving the vessel at a speed of 10 knots, a consumption equivalent to 26 days' steaming on the coal capacity of the bunkers.

The following is an account of the several trials as conducted by the Admiralty, viz.:—

1.—*Trial for Speed of H.M. Ship "Briton," with Compound or High and Low Pressure Engines of* 350 *horse-power nominal.*

Date of trial	19th May, 1870
Where tried	Maplin Sands, Sheerness.
Draught of water forward	13ft. 5in.
" " aft	16ft. 11in.
" " mean	15ft. 2in.
Diameter of cylinders, high pressure	57in.
" " low "	100¼in.
Stroke of Piston	2ft. 9in.

	Full Power.	Half power.
Pressure of steam in boilers (average)	58lbs.	58lbs.
Vacuum in condenser	27in.	27¾in.
Revolutions (mean) per minute	95·25	75·47
Mean pressure in cylinder (small)	25·966lbs	17·15lbs.
" " (large)	8·75lbs.	3·725lbs.
Indicated horses-power	2,148	933
Speed of vessel in knots	13·126	11·026
Diameter of screw (Griffith's two-bladed)	14ft. 9in.	
Pitch of ditto	16ft.	
Temperature in engine-room	58° Fah.	

2.—*Trial to test the Consumption of Coal at Full Power.*

Date of trial	2nd June, 1870.
Indicated horses-power	2,018
Coal consumed per hour	4,000lbs.
Do. per indicated horse-power per hour	1·98lb.

3.—*Trial to test the Consumption of Coal at a* 10-*knot Speed of the Vessel.*

Date of Trial	10th June, 1870.
Indicated horses-power	660
Coal consumed per hour	860lbs.
Do. per indicated horse-power per hour	1·3lb.
Coal capacity of bunkers	240 tons.
Number of days steaming at a 10-knot speed on the coal contained in the bunkers	26

STEAMER OMNIBUS.

An experiment which was made recently on the streets of Edinburgh with the new patent road steamer and patent omnibus, invented by Mr. R. W. Thomson, must have satisfied those who witnessed it that a new era in locomotion, so far as our large towns and public roads generally are concerned, has begun. At present all that need be said is, that the trial of the steamer and omnibus was sufficient to convince every one that a thoroughly safe means of locomotion has been provided by Mr Thomson, and that there is in it not merely no danger to the passengers who are conveyed, but also no fear of any injury being caused in the streets through which it may pass. It cannot hurt the pavement—that is sufficiently guarded against by the elastic tires of the wheels; while the unobtrusive manner in which the steam part of the machine is worked altogether prevents the danger of alarming horses, or any other of the risks which have hitherto attended the passage of traction-engines through crowded thoroughfares. It is perfectly under control, and can be regulated almost as nicely as a watch; and therefore, so far as it is concerned, there is no need for the elaborate precautions in the way of signalling and other things which, have been found necessary as to locomotives on common roads hitherto. Shortly after two o'clock in the afternoon the steamer started for Leith from Parliament-street, the omnibus being occupied by the Lord Provost of Edinburgh, Bailies Miller, Fyfe, Russell, and Skinner, Dean of Guild Russel, Treasurer Marshall, Convener Field, Councillors Colston, Cranston Tawse, Millar, Bladworth, Durham, Mackay, Sloan, Macknight, Somerville, Crichton, Mossman, Younger, Robertson, Temple, Rowatt, Gordon, and Mitchell, Edinburgh; and Bailies Pentland and Steven, and Councillors Blanshard, Garland, Lundie, and Forsyth, Leith; the Revs. George Murray and William M'Lean, and a number of other gentlemen. In Parliament-square and High-street a large crowd congregated to see the steamer start, and along the route—which was up High-street, along Castle-terrace, Lothian-road, Princes'-street, and down Leith-walk, to Leith—there was a numerous body of people following it. On arriving at Constitution-street, Leith, the engine turned right round, and the party drove back to Edinburgh. Not the slightest hitch occurred on the journey. The omnibus came straight up the steep place at Leith-street with its load, turned without stopping at the foot of Leith-walk with more ease than horses could have done, and took its place among the usual traffic so naturally and simply that it is evident it has been put into a practical and pleasing shape.

TRIAL TRIP OF THE MAIL STEAMER "ASIA."

The mail steamer *Asia*, which was recently launched from the shipbuilding yard of Messrs. J. Wigham Richardson and Co., of Newcastle, underwent her trial trip on the 20th ult. The *Asia* is a large vessel, being 1,400 tons burthen, and is intended to carry the mails, as well as passengers, from Genoa to Bombay, *via* the Suez Canal. She is the property of Messrs. R. Rubattino and Co., of Genoa—a firm owning no fewer than nineteen vessels employed in the same trade. The *Asia* is built to accommodate 170 first and 30 second class passengers, together with a crew of 50 hands. This is the third vessel that has been built for the same firm on the banks of the Tyne, and the following are some particulars of her dimensions. The length of the *Asia* overall is 260ft., breadth of beam 31ft., depth of hold 25ft., when laden she will only draw 19ft., which depth will allow her to pass with perfect safety through the whole length of the Suez Canal. The chief cabins of this fine vessel are fitted up with birds-eye maple highly polished, the main panels being embellished with excellent drawings on glass of Italian scenery; the state apartments of the officers of the ship are also fitted up with the same degree of elegance, whilst the second class passengers' apartments have been furnished with every attention to comfort. The order for the engines was entrusted to Messrs. Hawthorn, who have on this occasion turned out specimens of marine machinery that have never been surpassed on the banks of the river. The engines of the *Asia* are 140 nominal horse power, working up to 784 horse-power. They are high and low pressure compound engines, with surface condensers, and are supplied with steam from Messrs. Hawthorn's patent multiflue-boilers, working at a pressure of 75lbs. per square inch. The high-pressure cylinder is 30in., and the low pressure cylinder 60in. in diameter, the stroke of each 3ft. the angle of cranks is 150 degrees. The average speed on the run to and from the Coquet Island was eleven knots an hour, which surpassed the expectations of those on board. The consumption of coal was at the low rate of 16 tons per 24 hours, and was principally due to the high evaporative power of Messrs. Hawthorn's patent multiflue boiles. The quantity of coal on board the vessel when she made her trial trip was 1,120 tons.

CORRESPONDENCE.

We cannot hold ourselves responsible for the opinions of our Correspondents.

To the Editor of THE ARTIZAN.

SIR,—May I presume so far, in corroboration of your favourable allusion to the sugar-mills constructed on Mr. Buchanan's patent, as to offer a most interesting fact, which is as formidable as it is convincing. It is the accidental passage of a wrought-iron spanner, through the first pair of rolls, when the mill was in full work, and that without in the least deranging the mill. I came to that mill a few hours after the accident. The spanner betrayed the fact, in its flattened state. The mill belonged to Don Jose Martinez, of San Fernando, in the province of Pampanga, in the Island of Luzon. When we remember the casualties to which mills are liable, that the old-fashioned mill too frequently breaks down, when passing canes only, to the serious confusion of the whole establishment, the satisfaction is great to be in possession of a mill that can overcome ordinary difficulties. I may even go a step further, having erected the first mill, of Mr. B.'s manufacture, in the Phillippine Islands, several have been erected since, and they all remain intact. I write this in the interest of planters. Mr. Buchanan and I remain perfect strangers to each other.

Passing from this notice of the mill, will you permit me to submit opinions which rather differ from yours, on a point which is *purely chemical*? However, you are not alone, when you give expression to the current popular error, "that cane-juice is naturally pure, and it is quite as easily made into good, as into bad sugar." My preference leans to the opinion of Dr. Scoffern, on a chemical subject with which few men are so familiar as he is admitted to be. He says, "all vegetable juices, which contain sugar, also contain various other substances;" so much for their "purity." Now for the *function* of these *impurities*, "which impede the crystallisation of sugar, and which *therefore require to be separated*. For the most part, the chemical agent thus employed [to effect the separation, the process is misnamed by the French 'defecation], is lime, a substance which has a tendency to change cane-sugar into grape-sugar, grape-sugar into caramel, and caramel into other and lower products of decomposition. Thus, is the sugar manufacturer beset with difficulties, from this peculiar cause [impurity] * * * which finally *results in the large destruction of sugar*."

From this we infer, that the "destruction of sugar" by the common process, is most easy, a matter of course; and experience confirms the inference.

Dr. Scoffern estimated the current produce of sugar at "two millions of tons per annum," and the monetary value "at the place of preparation, will be no less than thirty millions of pounds sterling per annum."

"Passing on, from a consideration of the annual amount of sugar *produced* from the cane, to the amount *lost in the process*, we find here a subject for painful contemplation. * * * There can be no question about this matter. It is not asserted by the advocates of any one process, or the other. All persons conversant with sugar, are unanimous in the statement, that, *at the lowest estimate*, for every weighed amount of sugar obtained, *an equal amount is lost* * * * no less than thirty millions of pounds sterling, per annum, [is lost] owing to imperfect methods of conducting the operation * * * this has been conceded by all chemists, who have turned their attention to the processes of native sugar extraction. So great a loss, is altogether without parallel in any other chemical art," *vide* Brande's lectures on Organic Chemistry, delivered at the Royal Institution, edited by Dr. Scoffern, and dedicated to Professor Faraday.

I have before me also, the last published "History of Sugar," by William Reed. He says, "what the sugar-grower would wish to do, if he could, is this: to acquire a more efficient purifying agent than lime; thereby removing foreign matters at once, and limiting the production of molasses. * * * Instead of merely getting out seven per cent of the eighteen to twenty-three, found in cane-juice, as now accomplished in the West Indies, he—Dr. Scoffern—has seen twenty per cent extracted from Spanish cane-juice. In the very first year of his patent, [for the use of the acetate of lead, instead of lime, which was a chemical success, and because it introduced a poison into the manipulation of food, it was ultimately abandoned], he sold a fortieth part of it for £2,000, and the sale was considered a favour. A London refiner, moreover paid him £1 per ton royalty on his produce, about £150 per week."

"If," says the same author, "If the composition of sugar-cane juice were merely a solution of sugar in water, the subsequent stages of manufacture would be most easy; but, unfortunately, it is a very complex product."

I apprehend I cannot have done better than proffer indisputable authority. Of course, I could multiply authorities, to the same conclusions, if necessary; and, if not presuming too far, I would add, that experience long since led me to similar results, which stimulated me to seek for a better mode of treating the juice. The loss of "no less than thirty millions of pounds sterling per annum" by sheer ignorance of a suitable treatment of a "complex product," is as formidable, as it is unsatisfactory, that, "for every weighed amount of sugar obtained, an equal amount is lost."

I apprehend it is because the planters continue unconscious of this serious annual loss, that they are so contented *with* it, although doubtless they might do better *without* it. I am aware that they repeat, just what tradition told them, "that the juice is *naturally pure*, and it is quite as easily made into good as into bad sugar," as if this difference were perfectly immaterial, and both qualities were the same value in the market. The assertion comes in all its deformity to solicit sympathy, and with the experience of more than a hundred years, to command respect. This respect must be very hollow when offered to dull routine, seeing that it entails an immense loss, and offers an excuse which is a fallacy of its own creating, a fallacy which chymistry has—years ago—exploded, and continues to expose unto this day. Routine lays it down as law, that it is impossible to get a crystallised sugar in the absence of lime, or some other alkali, to neutralize the acid which ignorance there accumulates, yet anybody can get a beautiful "grocer's sugar" direct from the cane-juice, without the assistance of an alkali, or the impediment of an acid. It has been done repeatedly, and of course it can be done again; not having been done by accident, but on scientific principle, by design. Routine is equally dogmatic on the impossibility to make sugar from the juice of damaged—as rat gnawn—sugar canes, and therefore commands that such canes be thrown away; yet anybody can collect them immediately after the harvest, and get "first-class, well crystallised sugar" from their juice, and "25 per cent. more sugar" than is ordinarily obtained, by the common process, from the best canes of the same field.

Engineers continue to do much for the mechanical part of the sugar-manufacture, but they cannot do everything.

Sugar, from the beet-root, is largely increasing in the market, and to that extent it is supplanting the cane-sugar. This beet sugar tempts the refiner, by the greater economy with which it passes through his filter, and it is only through this filter that it can come into the hands of the grocer. This superior filter economy helps the foreign refiner to compete with, and in fact, to undersell the English refiner in his own home market, who uses the cheaper low quality cane-sugars, and six times more animal carbon to purify them.

The refiners on the Clyde understand this, and now refuse the low quality, impure, cane-sugars. Home growers too know this, and may be ultimately led by a temporary, a successful speculation, with beet sugar, into a false position.

Whenever the growers of sugar-cane throw off the yoke which routine imposes, and realise more sugar, of a superior class, from the same acreage as at present, and at a similar cost, which is both *possible* and *practicable*, then cane-sugar will come direct into the grocers' hands, which beet-root sugar cannot, and cane sugar, as a rule, does not. If it were "quite as easy to make the juice into good as into bad sugar," the grocer would be the buyer direct, at a better price; instead of paying that better price to the refiner, *after* he has made the sugar saleable, paid his large establishment charges, and secured a commensurate profit for himself.

As a consequence of the introduction of the beet sugar, the low-class cane-sugars will remain untouched by the refiner, as they are already neglected by the grocer.

The amount of capital at stake may be too important to induce apathy, or invite indifference to improvement much longer.

Another class of facts perhaps may elucidate my position more clearly. We have them arranged by that able analyst, Dr. Wallace, for the refiners of Greenock. The Doctor has found the French mode of estimating the value of sugars to be a fair one in practice. It is based on two assumptions:—1st. that each per centage of fruit, or, uncrystallisable sugar, prevents the crystallisation of an equal amount of cane-sugar; and, 2nd, that each part of soluble salt prevents the crystallisation of five times its weight of cane-sugar. Three specimens will suffice here.

	100 of Cuba Muscovado.	100 of Unclayed Manilla.	100 of French Beet.
Raw Cane Sugar	92·35	79·00	93·80
Fruit Sugar	3·38	11·76	0·15
Extractive, &c.	0·66	1·32	0·87
Salts, soluble	0·62	1·95	1·30
„ insoluble	0·15	0·63	—
Water	2·84	5·34	3·88
Colour, D. S.	13·00	6·00	13·00
Cane Sugar obtainable	85·90	57·5	87·10
Loss in refining	14·10	42·5	12·90

Dr. Wallace adds this very prudent remark, that "although these analyses must not be considered as typical of the various kinds of sugars, for, *all of them vary exceedingly*, yet we get a fair idea of descriptions of sugars used in refineries." Thus we accumulate English, French, and Scotch experience, and find a confirmation in the fact, that, "raw sugars" are impure, and their impurities are so many causes of the immense loss of sugar in every stage of their manufacture. We may also see how the beet sugars are supplanting the low-quality cane sugars. It need not be so, when the latter are susceptible of improvement in the process of proximate manufacture, so as to equal the best "grocers' sugars." In point of fact, all cane sugars can be brought to that high standard of quality, with perfect economy, common prudence, and a great profit. *Ex. gra.*:—Take the gross income on sugar sales of an estate at £1,000 per annum, and assume the nett profit at £200; and the increase of product of a better quality, at the minimum—as already explained—we thus double the gross income, and bring it up to at least £2,000

And, allow expenses to rise—even to 1,000

Then, the nett profit, at present prices, rises from £200 to £1,000

I am, Sir, yours faithfully,

14, Englefield-road, London, N. W. E. Gill.

[If our correspondent will look again at the article he calls in question, he will see that in it there is no mention whatever respecting the purity or impurity of cane juice.—Ed. Artizan].

NOTES AND NOVELTIES.

MISCELLANEOUS.

The Welsh Iron Trade.—During the last few months there has been a marked degree of improvement in the iron trade of South Wales, and the works are now, as a rule on full time. Important Russian and American engagements are under execution, and orders for railway iron are offered so freely that no difficulty is experienced in securing the full current quotations. The transfer of the Blaenavon iron works and mineral estate is announced to a limited liability company, with a capital of £600,000 of which £450,000 is to be called up. The property is one of the most extensive and valuable in Monmouthshire, extending over 10,000 acres, and the iron produced has always borne a high reputation as regards quality. The Ynyseedwyn Works, in the Swansea Valley, after having been closed for some time, are about to be re-started, and the necessary repairs are now going on. At several other establishments steps are being taken with the view of increasing the make.

Monthly Report of the Hartford (U.S.) Steam Boiler Insurance Company.—The above-named Company makes the following report of its inspections for the month of March:—During the month 458 visits of inspection have been made, and 784 boilers examined. 731 externally and 224 internally, while 69 have been tested by hydraulic pressure. The number of defects in all discovered were 482, of which sixty are regarded as dangerous. The defects in detail are as follows:—Furnaces out of shape, 7—one dangerous. Fractures in all, 30—seven dangerous. Burned plates, 26—five dangerous. Blistered plates, 73—fifteen dangerous. Cases of incrustation and scale, 81—twelve dangerous. Cases of sediment and deposit, 5. Cases of external corrosion, 34—four dangerous. Internal corrosion, 6—five dangerous. Cases of internal grooving, 7—one dangerous. Water-gauges out of order, 25. Blow-out apparatus out of order, 7—one dangerous. Safety-valves overloaded, 24—one dangerous. Pressure gauges out of order, 92—two dangerous. These varied from—10 to + 25. Tubes corroded off near tube sheet, 1—one dangerous. Boilers malconstructed, 1—regarded as dangerous. Boilers condemned as unsafe and beyond repair, 4.

The Austrian Lloyd Company has published a reduced tariff for goods sent to Calcutta *via* Suez. According to this tariff the charge for a package of 20 cubic feet, weighing 600 lb., will be £2 1s. instead of £3 5s.; and for a package of 30 cubic feet, weighing 600 lb., £2 15s. 1d. instead of £4 10s. 6d. The charge for goods weighing more than 25 lb. per English cubic foot will be £3 a ton up to 2,000 tons. The freight for money will be 1½ per cent., and the premiums for marine insurance 1 per cent. The second-class fare for passengers, inclusive of provisions, is £12 1s. from Trieste to Suez, £25 from Trieste to Aden, and £40 from Trieste to Bombay.

STEAM SHIPPING.

Rapid Steaming.—Messrs. Gibbs, Bright, and Co., of Liverpool, have received intelligence that the auxiliary screw steamer *Great Britain* arrived at Melbourne after an extraordinarily rapid passage of 56 days.

LAUNCHES

Glasgow.—Messrs. Dobie and Co., near Govan, launched on the 24th May an iron screw steamer of 200 tons burthen, for Messrs. Doward, Dickson and Co., of Liverpool, to trade between Dumfries, Whitehaven, and Liverpool. Miss Hendry, daughter of Councillor Hendry, of Greenock, named her the *Burns*.

On the 6th ult, Messrs. A. M'Millan and Son launched from their building-yard at Dumbarton a handsome iron barque, of about 400 tons register, for Henry Browse, Esq., jun., London which was named *Glaslyn* by Mrs Milner, wife of the captain. The *Glaslyn* is built to the highest class at Lloyd's, and is intended for the China trade.

Messrs. Blackwood and Gordon launched from their shipbuilding yard at Port-Glasgow, on the 10th ult, a small screw steamer named the *Fram*. She is intended for the Norwegian fish trade, and has been built to the order of Messrs Turnbull and Salvensen of Glasgow.

On the 14th ult there was launched from the iron shipbuilding yard of Messrs. Robt. Steele and Co., Greenock a splendid steam yacht of about 450 tons o.m., which was named *Palatine*. The *Palatine* is of the following dimensions:—Length, 170ft.; breadth of beam, 25ft,; depth of hold, 14½ft. She is the property of the Earl of Wilton, and will be under command of Captain Brown.

Messrs. Barclay, Curle and Company Glasgow launched on the 16th ult, a spar decked iron screw steamer of about 1,550 tons register, which they have built to the order of Messrs. G. S. Seater and Co., Leith. The vessel's dimensions are:—Length, 265ft.; breath, 33ft.; depth, 24½ft. Her engines, on the compound principle, are of about 130 horse-power. Her name, the *Seagull*, was given by Miss Ferguson, Larkfield, Partick.

H.M.S. *Sultan*, 12, iron armour-plated ship, 5,226 tons, 1,200-horse power, which has been building in No. 2 dock at Chatham, was launched or "floated out" on the 31st of May in the presence of a large crowd of spectators. The ceremony of christening was performed by a daughter of his Excellency Musurus Pasha, the Turkish Ambassador to the Court of London. The *Sultan* is a broadside ship and was designed by Mr. E. J. Reed, the Chief Constructor of the Navy. Her first plate was laid on the 1st of August, 1868. The following are the dimensions of the ship:—Extreme length, 338ft. 6in.; extreme breadth; 59ft.; depth in hold, 21ft. The *Sultan* will be a most formidable vessel. She is ranked in the "Navy List" as a 12-gun ship, and she will carry 12 very powerful guns, but on her upper deck she will have in addition a number of guns of smaller calibre. The main deck battery will consist of eight 18-ton guns, the two most forward of which can, by the construction of the port-holes, like those of the *Hercules*, be fired lmost straight ahead. There will also be two guns of less weight and well protected in the bow of the vessel. But the special feature of the ship is an upper battery, at the after end of the main deck battery, semicircular in form, the rounded ends projecting somewhat over the sides of the ship, which will contain two 12½-ton guns, mounted on Captain Scott's carriages so that they can by fired in almost every direction fore and aft and as part of the broadside.

At Jarrow on the 15th ult the *Swiftsure* armour-plated frigate, built from designs by Mr. Reed, for the Government, was launched from the building yard of Palmer and Co. (limited), in the presence of a great concourse of people. The *Swiftsure* is a frigate of 3,892 31-94 tons register, and is 290ft. 9in. in length over all; length between perpendiculars 280ft.; extreme breadth from outside of wood sheathing 55ft.; extreme depth amidships from deck over battery to the keel, 36ft. 6in. Being intended for a ram as well as a battery the stem is exceedingly strong and projects in the lower portion in the ram form. The lower portion of the stem is formed of the best gun metal, and weighs nearly 18 tons, while the gun metal used in the stern frame and the rudder weighs no less than 47 tons. The principal keel is made exceedingly strong, and to give additional security to the ship a false keel 12in. thick and 21in. in breadth is placed at the extreme bottom, and is so fixed that should the *Swiftsure* at any time touch the ground slightly in moderate weather she will glide from the shoal and leave her false keel behind without sustaining any material injury.

TRIAL TRIPS.

THE NEW CUNARD LINER "ABYSSINIA."—This great steamship, of 3,600 tons went out npon her Admiralty trial on May 20th, and ran the measured mile at Wemyss Bay at the rate of 15 knots per hour. The *Abyssinia* is one of the four new ships fitting out in the Clyde to carry the mails between this conntry and North America, under Messrs. Cunard, Burns, and M'Iver's contract, which, it will be remembered, they obtained from Her Majesty's Government for eight years, at £70,000 a year. The vessel is one of the finest specimens of naval architecture. The *Abyssinia* is unlike any of the Cunard steamers now afloat, as she is a four-decker, and with her heavy iron masts and plumb stem looks more like a line-of-battle ship than a vessel destined for the great maritime service of the Cunard company. The *Abyssinia* was built and engined by Messrs. J. and G. Thomson, who have now two other ships on the stocks for the same company.

DOCKS, HARBOURS BRIDGES,

SAN FRANCISCO HARBOUR.—Blossom Rock, a snnken rock of soft sandstone 180ft. long by 90ft. wide, has been known and dreaded as the most dangerous obstruction in the line of entrance to the harbour of San Francisco. The water at the rock at low tide was but about 5ft. and the current was generally very strong. The buoys marking the position have several times been swept away. The rock itself was removed on the 23rd of April. Shafts having been sunk and a great excavation made, no less than 23 tons of gunpowder were introduced in large tanks or cylinders connected by electric wires, and at 2 p.m. the explosion occurred in the presence of a multitude of people, all keeping at a respectful distance. A monster cone of water shot into the air to the height of above 200ft. in the shape of a round or obtuse-pointed, truncated cone, somewhat resembling an inverted thimble. This column was nearly 300ft. in diameter at a point some 80ft. above the surface of the bay. Its base was shrouded by another outburst of water, which rose to the height of fully 80ft. all around the central shaft, and rolled its flood outward. The base was over 500ft. in diameter at the surface of the bay. High above the upheaved mass rocks of large size, ruins of the interior works, and a great quantity of earthy matter were thrown and scattered far and wide. The rock was utterly demolished, and thrown in all directions, and the soundings gave 38ft. of water over its site at low tide. In excavating the rock 2,500 cubic yards of rock were hoisted through the shaft and dumped into the bay, and the pile of loose rock thus created reached nearly to the surface of the water. Over this the soundings two days after gave 1 ft. of water, showing that the tide made great havoc with this rubbish in two days. In a week, it was expected, the depth of water called for by the contract would be found all about the site of the rock.

RAILWAYS.

A PROSPECTUS has been issued of the Bedford and Northampton Railway Company, with a capital of £400,000, in shares of £20, and debentures to the amount of £133,000. The line has been sanctioned by Parliament, and is 20 miles in length, being a continuation of the Midland from Bedford to Northampton, to which it establishes a direct route from London. The line is to be worked by the Midland Company.

THE North-Eastern Railway Company have established an increase in receipts this half year of £175,000, as compared with the corresponding period of 1869.

THE Northern Extension Railway of South Australia has been opened for general traffic beyond Chinkford. The Victoria Government has instructed its Agent General in London to procure six passenger and eight goods locomotives for the new lines in contemplation in Victoria; sixty engines in all will be required, but it is proposed to manufacture six in the colony.

MR. W. J. CUTBILL, the secretary of the Mont Cenis Railway Company has made the following statement in relation to the working of the line:—'The India mail *viá* Brindisi has crossed our line since the 15th October, 1869, and notwithstanding a most severe winter—at times the snow even interrupting the passenger traffic—the mail has always been carried through without a single exception. From the 1st November, 1869, to the 20th of May this year the railway has carried 18,896 passengers, and since the opening of the line, June 15th, 1868, there has not been an accident in the passenger service, with the exception of delays caused from the accumulation of snow during the severest part of the winter. The company has at the present moment eighteen engines in the service, four of which have been recently added; these are built by Messrs. Cail and Co., and are of a very powerful description."

ACCIDENTS.

FATAL EXPLOSION.—An inquest was held on the 3rd ult, at Lowestoft upon the body of Edward Rayner, a fireman employed on board the Great Eastern Railway Company's steamer *Rotterdam*. It appears that while steam was being got up for the purpose of working the donkey-engine, the boiler suddenly exploded, killing Rayner and severely scalding Robert Graham, the engineer. But little injury was done on board the vessel beyond the fracture of the inner coating of the boiler and the blowing off the funnel, which fell upon a roof close by, damaging a few of the slates. The engines and boiler were examined a few days before the explosion by Mr. Traill, Government Inspector, who was satisfied with everything except two pipes, which required to be altered, but which had nothing to do with the donkey-engine. The boiler which exploded was tested twelve months ago at 100lb., and had not been at work more than 30 days since. At the time of the explosion the pressure is said not to have been more than 25lb. to the square inch.

THE railway from Geneva to Annemak was a few days since the scene of a fearful occurrence. An immense mass of snow and ice became detached from the Glacier of Monthoux, and fell upon a train that was passing at the moment. The last three carriages were crushed to fragments. Three passengers were taken out dead, and five others were more or less seriously injured. The disaster would have been much greater but for the presence of mind of the engine-driver, who, perceiving the falling avalanche, applied the full power of steam, and thus saved a portion of the train.

TELEGRAPHIC ENGINEERING.

SPEED OF ELECTRIC SIGNALS.—Professor Gould has found that the velocity of the electric waves through the Atlantic cables is from 7,000 to 8,000 miles per second, and depends somewhat upon whether the circuit is formed by the two cables or by one cable and the earth. Telegraph wires upon poles in the air conduct the electric waves with a velocity a little more than double this, and it is remarked, as a curious fact, that the rapidity of the transmission increases with the distance between the wire and the earth or the height of the support. Wires buried in the earth likewise transmit slowly, like submarine cables. Wires placed upon poles, but slightly elevated, transmit signals with a velocity of 12,000 miles per second, while those at a considerable height give a velocity of 16,000 or 20,000 miles.

THE Haverfordwest and Wexford cable has again parted, and until it has been repaired there will be some delay in the transmission of messages between this country and Ireland.

MINES, METALLURGY, &c.

THE United States Commissioner of Mining, Mr. Raymond, in his report to Congress, estimates the bullion product of 1869 as follows:—California, 20,000,000 dols.; Nevada, 14,000,000 dols.; Oregon and Washington, 4,000,000 dols.; Idaho, 7,000,000 dols.; Montana, 12,000,000 dols.; Colorado and Wyoming, 4,000,000 dols.; New Mexico, 500,000 dols.; Arizona, 1,000,000 dols. All other sources, 1,000,000 dols. Total 63,500,000 dols.

LATEST PRICES IN THE LONDON METAL MARKET.

	From			Tons.		
	£	s.	d.	£	s.	d.
COPPER.						
Best selected, per ton	73	0	0	74	0	0
Tough cake and tile do.	71	0	0	72	0	0
Sheathing and sheets do.	74	10	0	75	0	0
Bolts do.	76	0	0	„	„	„
Bottoms do.	78	0	0	„	„	„
Old (exchange) do.	63	0	0	„	„	„
Burra Burra do.	73	0	0	74	0	0
Wire, per lb.	0	0	10	„	„	„
Tubes do.	0	0	11	„	„	„
BRASS.						
Sheets, per lb.	0	0	$8\frac{1}{4}$	0	0	0
Wire do.	0	0	$7\frac{1}{4}$	„	„	„
Tubes do.	0	0	10	„	„	$11\frac{1}{2}$
Yellow metal sheath do.	0	0	$6\frac{1}{2}$	0	0	$6\frac{7}{8}$
Sheets do.	0	0	$6\frac{1}{4}$	„	„	„
SPELTER.						
Foreign on the spot, per ton	19	0	0	19	5	0
Do. to arrive	19	0	0	19	5	0
ZINC.						
In sheets, per ton	23	10	0	„	„	„
TIN.						
English blocks, per ton	135	0	0	137	0	0
Do. bars (in barrels) do.	136	0	0	138	0	0
Do. refined do.	141	0	0	„	„	„
Banca do.	134	0	0	„	„	„
Straits do.	133	0	0	„	„	„
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	6	6	1	8	0
IX. do. 1st quality do.	1	12	6	1	13	6
IC. do. 2nd quality do.	1	6	0	1	6	6
IX. do. 2nd quality do.	1	12	0	1	12	6
IC. Coke do.	1	3	0	1	3	6
IX. do. do	1	9	0	1	9	6
Canada plates, per ton	13	10	0	14	10	0
Do. at works do.	13	0	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	7	6	7	10	0
Do. to arrive do.	7	5	0	7	10	0
Nail rods do.	7	10	0	„	„	„
Stafford in London do.	8	5	0	9	0	0
Bars do. do.	8	0	0	9	0	0
Hoops do. do.	8	15	0	9	0	0
Sheets, single, do.	9	10	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	0
Bars, common, do.	6	15	0	7	0	0
Do. mrch. Tyne or Tees do.	6	10	0	„	„	„
Do. railway, in Wales, do.	7	10	0	„	„	„
Do. Swedish in London do.	9	10	0	9	15	0
To arrive do.	9	12	6	„	„	„
Pig No. 1 in Clyde do.	3	0	0	3	6	0
Do. f.o.b. Tyne or Tees do.	2	9	6	„	„	„
Do. No. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	17	0	6	0	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pig in London do.	6	5	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	13	10	0	13	15	0
Do. (hammered) do.	14	5	0	14	10	0
Do. in faggots do.	15	10	0	„	„	„
English spring do.	17	0	0	23	0	0
QUICKSILVER, per bottle	7	17	0	„	„	„
LEAD.						
English pig, common, per ton	18	2	6	18	5	0
Ditto. L.B. do.	18	2	6	18	5	0
Do. W.B. do.	19	0	0	19	5	0
Do. sheet, do.	18	10	0	„	„	„
Do. red lead do.	20	0	0	20	10	0
Do. white do.	27	0	0	30	0	0
Do. patent shot do.	21	0	0	„	„	„
Spanish do.	17	10	0	17	15	0

*At the works 1s to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETERS PATENT.

WE HAVE ADOPTED A NEW ARRANGEMENT OF THE PROVISIONAL PROTECTIONS APPLIED FOR BY INVENTORS AT THE GREAT SEAL PATENT OFFICE. IF ANY DIFFICULTY SHOULD ARISE WITH REFERENCE TO THE NAMES, ADDRESSES OR TITLES GIVEN IN THE LIST, THE REQUISITE INFORMATION WILL BE FURNISHED, FREE OF EXPENSE, FROM THE OFFICE, BY ADDRESSING A LETTER, PREPAID, TO THE EDITOR OF "THE ARTIZAN."

DATED MAY 23rd, 1870.

1480 J. Macqueen—Carding engines
1481 W. E. Heath—Cooling or refrigerating beer, &c.
1482 H. A. Bonneville—Wooden floors and wainscots
1483 H. A. Bonneville—Sewing machines
1484 P. C. Evans and H. J. H. King—Feeding wool to carding machines
1485 M. Benson—Supplying lamps with atmospheric air
1486 A. Long—Regulating the supply of water and other liquids
1487 W. E. Newton—Grinding saws
1488 A. Browne—Screw propellers
1489 J. Head—Setting boilers
1490 W. R. Lake—Scouring and otherwise treating leather
1491 W. R. Lake—Sewing boots
1492 J. A. de Carvalho—Ships
1493 M. Henry—Improved case holder for matches, &c.

DATED MAY 24th, 1870.

1494 H. C. M. Ximenes and E. Betincourt—Preserving building materials
1495 J. Fletcher—Coking
1496 E. A. Leigh—Improvements in shafting and in transmitting power
1497 E. Walhank—Fittings of uppers in all kinds of boots
1498 E. Leigh—Piles
1499 H. B. Brook—Medicinal compound
1500 W. E. Newton—Earth closets
1501 B. Hunt—Fastening French or folding windows
1502 A. Cochran—Discharging water from steam pipes
1503 J. H. Johnson—Metal cop tubes
1504 J. Yule—Engines
1505 T. J. Mayall—Footballs
1506 W. R. Lake—Apparatus for the rollers of spinning frames
1507 R. H. Pounds—Ropes
1508 L. Perkins—Fire engine hoses and pipes

DATED MAY 25th, 1870.

1509 C. Topham—Machines for mincing and dividing meat
1510 J. S. Starnes—Improved ventilator for cabins of ships
1511 J. McNaught and W. McNaught—Washing wool
1512 W. R. Lake—Washing machines
1513 C. W. Siemens—Gas furnaces
1514 G. Thomas—Gas stoves
1515 J. W. Horsfall—Ventilating mines
1516 J. Falconer—Improvements in machinery for felting
1517 J. Shanks—Wheels
1518 S. E. T. Stenner—Fire escapes
1519 A. M. Clark—Cutting wood screws and eye bolts

DATED MAY 26th, 1870.

1520 C. E. Barton—Breaking ice for the preservation of fish, &c.
1521 R. Cardwell—Fire grates
1522 J. Appleton and R. C. Ross—Finishing printed paper
1523 G. Schuck—Machine for watering and sweeping streets
1524 D. Jones—Treatment of coal gas
1525 G. Lungs—Treatment of grass
1526 J. Bullough—Looms, &c.
1527 J. Bernard—Furnaces, &c.
1528 J. Webster—Converters for the manufacture of steel
1529 W. Horton—Centre bits
1530 B. Cooper—Looms
1531 J. Eastwood and H. W. Whitehead—Combing wool, &c.
1532 W. E. Newton—Looms
1533 W. Arnold and W. Carnelley—Improvements in steam boilers
1534 L. Walker and F. A. Walker—Improved setting fid
1535 W. Mulsm—Furnace, &c.
1536 J. Bernard—Treatment of ores

DATED MAY 27th, 1870.

1537 W. Astrop—Motive power
1538 A. Frerichs—Spinning cotton
1539 J. J. Turner—Washing machinery
1540 G. Zeller—Firearms
1541 W. Morgan—Axles, &c.
1542 R. Gammon—Permanent ways
1543 J. Sellers—Mileage indicators
1544 J. Henderson—Purifying cast iron for foundry purposes
1545 P. G. B. Westmacott—Grinding or polishing glass, &c.
1546 H. Blandy—Vessels employed in the manufacture of nitrous oxide gas
1547 H. Rose—Attaching mineral teeth to a plate or back
1548 J. and W. Dargue—Bleaching
1549 B. J. B. Mills—Steam generators
1550 J. Cope—Steam engines
1551 H. A. Bonneville—Firearms
1552 H. A. Bonneville—Label holder
1553 W. E. Gedge—System of grooves for rolling iron
1554 W. E. Gedge—Plough
1555 G. Stevens and J. Hendy—Magnetic motor for sewing machines
1556 W. S. Moore—Hand mirrors
1557 W. J. Schlesinger—Rotary motion
1558 F. Tommasi—Thermo press
1559 H. Bessemer—Steamships, &c.

DATED MAY 28th, 1870.

1560 W. Cleland—Exhausting gas
1561 S. H. Stephens—Machines for grinding tin and other ores
1562 A. Manbree—Conversion of cereal and vegetable matters, &c.
1563 E. A. Stubbin—Cameras
1564 G. T. Leitch—Agricultural implement
1565 W. T. Small—Supply and exit of water to aquariums, &c.
1566 A. M. Clark—Corrugating and moulding sheet metal
1567 R. J. Collins—Embossed fabrics
1568 R. P. Williams—Railway switches

DATED MAY 30th, 1870.

1569 C. D. Abel—Sockets, &c.
1570 C. D. Abel—Tubes
1571 C. D. Abel—Drawing tube skelps
1572 W. Farini—Apparatus to be employed in gymnastic performances
1573 H. Bryant—Illustrating the motions of some of the heavenly bodies
1574 W. Beamish—Iron kerb
1575 C. Mather—Sizing yarn
1576 J. F. Wiles—Improvements in electro magnetic engines
1577 W. E. Gedge—Knitting machines
1578 A. V. Newton—Looms
1579 L. Mignot—Making ice
1580 H. Bessemer—Steamships &c.

DATED MAY 31st, 1870.

1581 P. D. Hedderwick—Printing
1582 A. Dyson—Carding wool
1583 L. Gardner and T. Bushby—Pill making machines
1584 B. Hunt—Electro magnetic apparatus for panoramas
1585 W. E. Newton—Inkstand
1586 S. Cohne—Disinfecting powder
1587 J. Leighton—Ornamenting the margins of books
1588 W. J. Barron and E. C. Barron—Soles and heels for boots

DATED JUNE 1st, 1870.

1589 J. B. Carruthers and S. Alley—Improvements in wheels
1590 R. Hughes—Scraping and cleansing streets and roads
1591 G. Lowry and S. Brookes—Machinery for hackling flax
1592 W. Winter—Winding thread
1593 C. D. Abel—Phosphorus
1594 A. M. Clark—Peat for fuel

DATED JUNE 2nd, 1870.

1595 J. James—Compressing gunpowder into pellets
1596 T. Holder—Sandcrack boot or hoof covering for horses
1597 H. Scheuerle, D. Gugisperg, and C. Scheibe—Cut nails
1598 W. V. Pulliam—Couplers
1599 W. R. Lake—Couplings
1600 J. and T. Priestman—Dressing leather
1601 A. H. Brandon—Spinning machines
1602 F. Dingey—Pulverising ores, &c.
1603 A. V. Newton—Preventing the corrosion of iron
1604 W. E. Newton—Furniture springs

DATED JUNE 3rd, 1870.

1605 R. Leake and H. Larkin—Engraving rollers for calico printers
1606 E. W. Hodgetts—Rick cloths, &c.
1607 H. Timmins—Hinges
1608 A. Segard—Knitting machines
1609 M. Henry—Improved bit
1610 J. F. Rogers—Decorticating fruits
1611 W. R. Lake—Preventing alterations in bankers' cheques
1612 C. H. Murray—Pressing bricks, &c.
1613 A. V. Newton—Cleaning knives

DATED JUNE 4th, 1870.

1614 W. Haslam—Woven fabrics, &c.
1615 W. H. Taplin—Lasts
1616 J. Burley and L. Glover—Improved moustache support
1617 J. Oddy and H. W. Whitehead—Combing wool
1618 C. Kenney—Facilitating the mounting a horse or velocipede
1619 H. Briasmead and R. Lyons—Threshing machines
1620 E. Heycock—Suspenders
1621 C. Clarance—Firearms
1622 J. R. Jefferies—Ploughs
1623 S. Adams—Velocipedes
1624 J. H. Johnson—Furnaces
1625 E. Ratcliff—Lamps
1626 D. Spill—Compounds for insulating telegraph wires
1627 J. Gabb—Boiler and furnace
1628 J. B. Murrlees and W. R. Watson—Desicating sugar cane refuse

DATED JUNE 6th, 1870.

1629 S. Lake and G. Kingdon—Arrangements applicable to trawlers, &c.
1630 W. McLean—Hinges
1631 T. A. and C. D. Marshall—Attaching the devices for effecting the water mark in paper, &c.
1632 A. Johnson—Washing machines
1633 D. Bentley and J. B. Jackson—Rag engines
1634 A. W. Pocock—Meters
1635 T. Restell—Guns
1636 T. Lisbman—Grate bars and other parts of furnaces
1637 C. T. Forrest—Rails for railroads
1638 W. R. Lake—Preventing the corrosion of the bottoms of ships

DATED JUNE 7th, 1870.

1639 L. Rose—Stoppers for bottles
1640 W. Wilson—Gas for illuminating and heating from coal oils
1641 W. and D. K. West—Pressing cotton
1642 B. Holt—Horse shoes and in carriage and other wheels
1643 R. Doughty—Lace machines
1644 G. T. Bousfield—Treatment of slag and other vitreous material
1645 J. Morris—Shedding power loom warps
1646 T. Aveling and Henry Rawlinson—Expansion gear for steam engines
1647 J. Storer—Fountains
1648 F. Schafer—Protecting shop fronts
1649 W. R. Lake—Testing strain or pressure applied to solid bodies

DATED JUNE 8th, 1870.

1650 A. Piccaluga—Manufacturing iced beverages
1651 G. Lodge and G. Sheard—Furnaces
1652 H. W. Hammond—Cartridges
1653 E. Clarke and J. Hughes—Safety cages for mines
1654 W., T. and J. Dewhirst—Bleaching, &c.
1655 E. Green and J. Cadbury—Fastenings for articles of dress
1656 H. Bolinger—Dividing and condensing fibrous materials on carding engines
1657 W. R. Lake—Printing telegraphic apparatus
1658 W. E. Newton—Cartridge cases
1659 T. Greenwood—Drawing wool
1660 J. H. Johnson—Producing light from heavy hydrocarbons
1661 G. T. Bousfield—Knitted fabrics
1662 E. Moss—Leather for mill bands

DATED JUNE 9th, 1870.

1663 W. L. Wrey—Propelling ships
1664 J. W. and W. D. Butler and J. Dunbar—Supplying coal to gas retorts
1665 J. Scoble—Packing for pistons
1666 W. T. Wright and E. Yorsth—Raising and lowering hay, &c.
1667 W. and T. R. H. Fisken—Cultivating land by steam or other power
1668 Z. T. Gramme and E. L. C. d'Ivernois—Magneto electric machines
1669 F. W. Webb—Ladels for molten metals
1670 C. D. Abel—Rendering corks impermeable to decay
1671 O. C. Stone and W. Pridgeon—Governing steam engines
1672 W. Kay—Washing surfaces
1673 J. D. Brunton—Ventilation of tunnels
1674 C. A. Calvert—Indicating the number of passengers carried in public vehicles
1675 W. E. Newton—Steam boilers
1676 P. Spence—Alum
1677 J. H. L. T. Portner—Sewing machine stands

DATED JUNE 10th, 1870.

1678 H. R. Fanshawe—Towels
1679 R. T. Y. Johnson—Rotary engines
1680 J. T. Parlour—Raising sunken ships
1681 W. Polson—Treating farinaceous substances
1682 B. Hunt—Joint for pipes
1683 W. Bush—Carriages

DATED JUNE 11th, 1870.

1684 J. Walker and A. E. Ragon—Ships
1685 T. Greenwood and J. Keats—Sewing machines
1686 F. G. Fleurr—Water waste preventer
1687 W. R. Lake—Embroidering attachment for sewing machines
1688 J. Combe—Winding cops for warp
1689 A. F. Brophy—Staining wood
1690 D. and J. Greig—Separating the fibres of fibrous substances
1691 B. J. B. Mills—Steam vessels, engines, boilers, and propellers

DATED JUNE 13th, 1870.

1692 F. W. Granham and B. Butterfield—Muzzles for dogs
1693 R. Punshon—Ships' compasses
1694 M. Henry—Eye glasses
1695 D. C. Lowber—Wire ties for securing bales of merchandise
1696 W. R. Lake—Ships' rudders
1697 E. T. Hughes—Preparing pure carbonate and bicarbonate of soda, and also soda in its crystallised state
1698 F. J. Knewstub—Travelling bags, &c.
1699 G. Lewis—Harvesting machines

DATED JUNE 14th, 1870.

1700 R. Blackhee—Surgical instruments known as Specula
1701 H. Hammond—Mixing soils
1702 W. Moore—Securing bolts
1703 W. A. Chandler—Carriage wheels
1704 A. Ford—Applying moisture and heat to the animal frame
1705 G. Wells—Ventilation and extinguishing fires on board ships
1706 B. G. Sloper—Treatment of sewage
1707 G. and J. Weir—Slide valves
1708 A. V. Newton—Forming bats of wool for felting purposes

DATED JUNE 15th, 1870.

1709 J. H. Johnson—Pressing and forming heels for boots
1710 F. Dupuy—Anti-hemorrhoidal plate
1711 C. H. Pennau—Coal vases
1712 A. B. Berard—Fusion of cast iron
1713 H. Law—Supplying water to lavatories, and water closets
1714 M. Jacob—Retaining carriage windows in any desired position
1715 R. Miller—Earthenware pipes
1716 J. H. Johnson—Employment of certain animal substances as fertilising agents
1717 J. Fossard—Bellows for lighting fires
1718 W. J. Hopkins—Roofs of houses

DATED JUNE 16th, 1870.

1719 W. Gadd—Looms for weaving
1720 H. B. Fox—Venetian blinds
1721 W. A. Clayton—Screw propellers and steering apparatus
1722 E. C. Rolls—Reed musical instruments
1723 J. Swain—Furnaces
1724 W. R. Lake—Steel washers
1725 J. H. Brierley—Ornamenting of fastenings for braces
1726 W. E. Newton—Paint brushes
1727 W. E. Nawron—Cigars
1728 B. F. Weatherdon—Breaking stones
1729 H. H. Kromschroeder and W. P. Randall—Gas meters

DATED JUNE 17th, 1870.

1730 G. S. Fleming—Corks
1731 W. Hadfield—Looms
1732 G. Farmer—Indenting of iron for shoe heel tips
1733 C. Joseph—Gas burners
1734 G. E. Lee—Tilt and forge hammer heads and their hursts and tail pieces
1735 W. B. Smith—Coating for Bickford's safety fuze
1736 C. A. Bluemel—Walking sticks and umbrella sticks
1737 H. E. Newton—Looms
1738 J. A. Lindblad—Bottles, and device for uncorking the same
1739 W. Amblor and B. Jowett—Indicating the times of trains to arrive at and depart from railway stations, &c.
1740 G. O. Wray—Fastenings for boxes
1741 T. Greenwood and J. Fabinn—Bagatelle and billiard cues
1742 H. Bessemer—Ships
1743 L. A. Ritterbandt—Peat charcoal
1744 C. M. Campbell—Mosaic plaques or slabs for decorations
1745 Sir J. Whitworth—Firearms
1746 T. J. Smith—Caustic soda
1747 E. Partridge—Axle boxes and securing the same upon the axle

DATED JUNE 18th, 1870.

1748 A. M. Clark—Bells
1749 A. S. Stocker—Bottles
1750 T. J. Smith—Treating pyrites
1751 W. E. Gedge—Cutting corks
1752 J. O. Ewing and J. J. Coleman—Treating lubricating oils
1753 J. J. Lundy—Lubricating animal materials in the process of manufacture
1754 B. J. B. Mills—Doffing and dividing apparatus applicable to continuous cards
1755 A. M. Clark—Raising sunken bodies

DATED JUNE 20th, 1870.

1756 C. D. Abel—Testing the quality of malleable metals
1797 L. Heim—Blacking
1758 J. de Weweirne—Dyeing

DATED JUNE 21st, 1870.

1759 W. Rainford—Wardrobes
1760 C. J. Fox, R. Larchin, and J. Dudd—Mangling machines
1761 J. Outram—Rotary engines
1762 G. Atterbury and G. Whitehouse—Communicating on railway trains
1763 H. T. Davey—Washing linen, &c.
1764 W. R. Lake—Securing the cables and standing rigging of ships
1765 A. C. Bamlett—Reaping machines
1766 B. J. Baruard Mills—Soap
1767 J. Bullough—Slasher sizing machines
1768 T. C. Brown—Valves applicable to steam or water pressure
1769 C. L. Frauke—Steel
1770 D. Collet—Bleaching
1771 J. H. Johnson—Railways, and in engines and railways to run thereon

DATED JUNE 22nd, 1870.

1772 I. Bates and J. Taylor—Bridges of the furnaces of steam boilers
1773 S. Neville—Plates of glass
1774 P. Boland—Yeast
1775 L. Hamel—Producing certain colours used in calico printing
1776 W. J. Cunningham and A. Dabb—Cutting type, &c.
1777 L. Megy, J. de Echeverria, and F. Bazan—Internal spring coupling and brake for regulating motion
1778 J. Reid—Steam engines
1779 T. Grnham and T. Dixon—Rotary engines
1780 E. Morewood—Tin plates
1781 J. J. Mendez—Ships
1782 G. Speight—Glue pot
1783 W. E. Newton—Obtaining glycerine from soap makers' spent lyes
1784 A. L. Horley—Bessemer steel

DATED JUNE 23rd, 1870

1785 T. Richmond—Healds employed in the manufacture of woven fabrics
1786 W. Spence—Egg boxes
1787 H. Povey and T. Roberts—Weighing grain
1788 A. Walker—Window sashes
1789 D. Forbes and A. P. Price—Manures

STEAM ROAD ROLLER

BY MR W. BATHO & MR T. AVELING

Fig. 1. Side Elevation

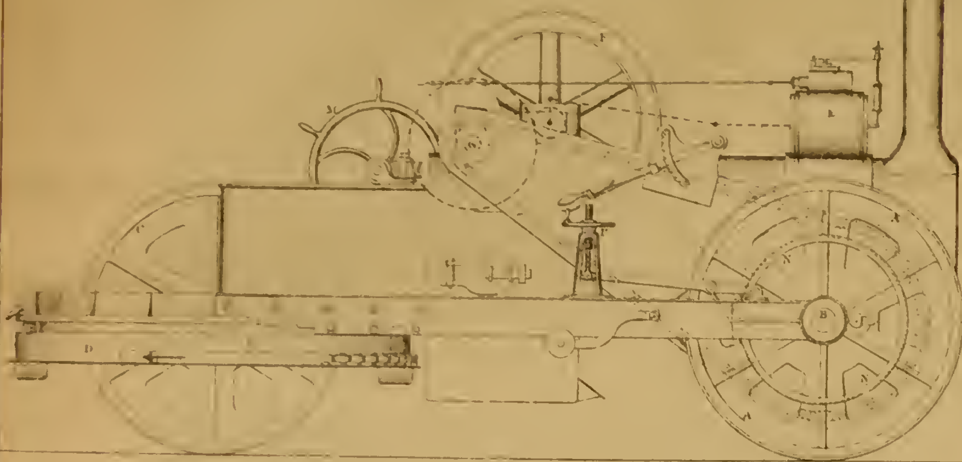


Fig. 2. Longitudinal Section

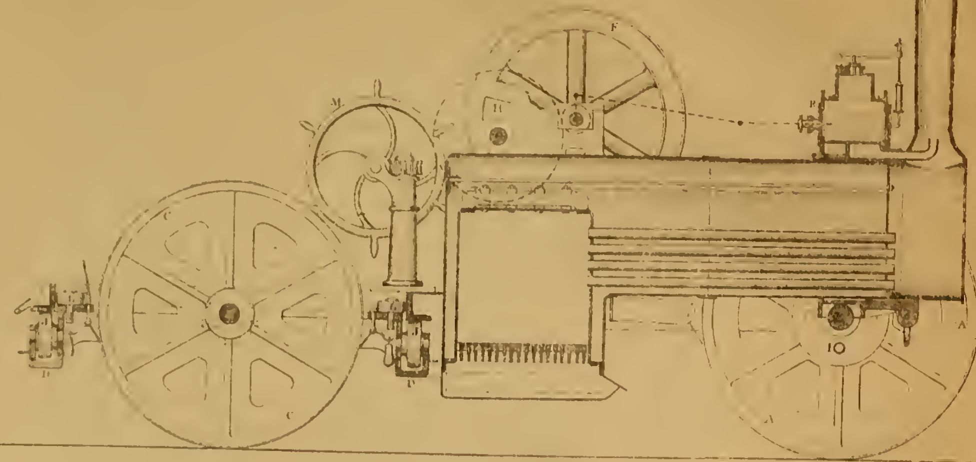


Fig. 3. Plan

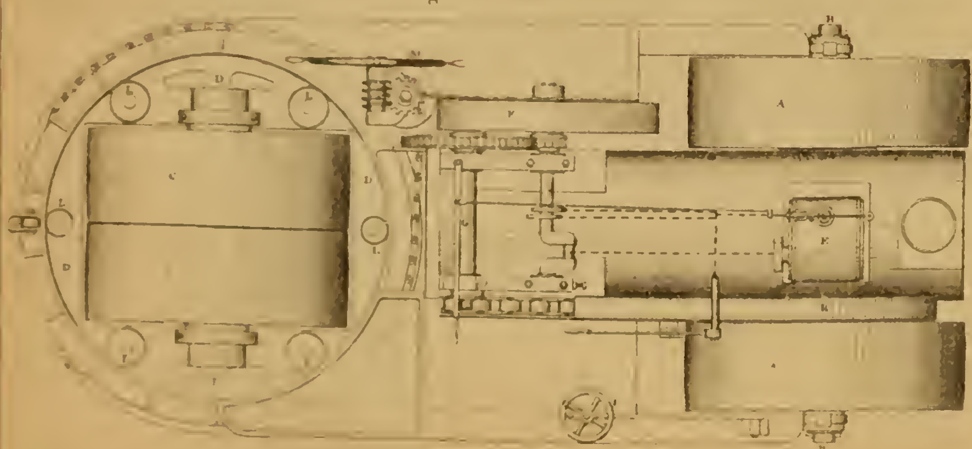


Fig. 4. Back Elevation

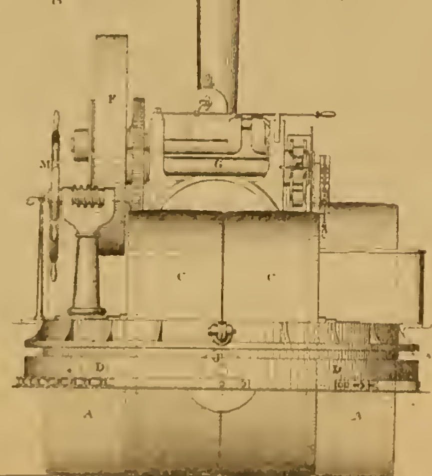
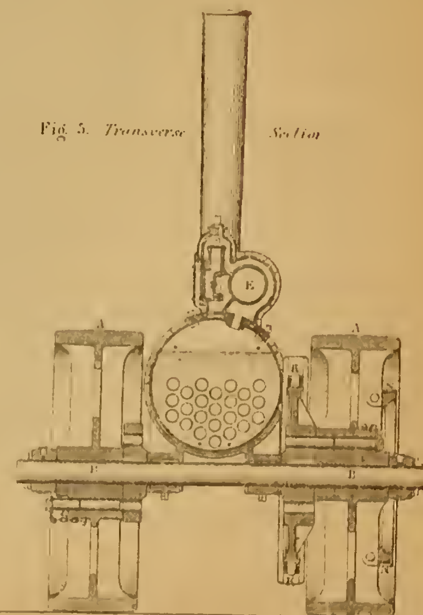


Fig. 5. Transverse Section



THE ARTIZAN.

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1st. AUGUST, 1870.

STEAM ROAD ROLLER.

By Mr. W. F. Batho, of Birmingham, and Mr. T. Aveling, of Rochester.
(*Illustrated by Plate* 363).

The substitution of rollers for horses' hoofs and carriage wheels, for the purpose of consolidating our roads, is slowly but steadily on the increase: and although municipal bodies are proverbially slow to perceive, and still slower to adopt any improvement whatever, it is evident that the advantages of employing steam road rollers is so great that, by degrees, every important district will be compelled to use them. We, therefore, make no apology for giving a drawing of one of the simplest kind (Plate 363), together with an abstract of the description read before the Institution of Mechanical Engineers by Mr. W. F. Batho:—

The idea of employing steam power in place of animal labour for rolling down newly macadamised roads originated with the chief engineer to the Calcutta municipality, Mr. W. Clark, whose attention had been drawn to the subject by experiencing the expense and difficulty attending the employment of bullocks for drawing rollers over the Calcutta roads. A steam road roller was consequently designed for him by Mr. Batho, which was sent out to Calcutta, and has done good work there during the last seven years, notwithstanding the defects in details attending a first and experimental design; and this steam roller has long since cleared its first cost by the saving in cost of its work compared with that done by rollers drawn by bullocks.

The principle of the machine is the use of three rollers arranged in a triangle, one roller on each side of the machine at the one end, and the third roller in the centre at the other end; the two side rollers are driven by the engine by means of pitched chains, and the centre roller is mounted in a turntable frame so as to swivel horizontally for the purpose of steering. The third roller is made wide enough to cover the intermediate space between the two side rollers, and the weight of the boiler and engine, which are vertical, and placed in the centre of the machine, is distributed over the three rollers. The results of trials carefully made to determine the difference in cost of working with this steam roller as compared with the ordinary plan of rolling by bullocks, for rolling an area of road of 44,631 square yards, gave £146 4s. 6d. as the cost of steam rolling, and £269 5s. 9d. as the cost with bullocks, being a saving of forty-six per cent. in cost with the steam rolling, in addition to the economy arising from the much superior and more durable nature of the work done.

A steam roller on a different principle was subsequently constructed in France, which has now been extensively used for several years in Paris, and has thoroughly proved on a large scale the great practical value and economy of steam rolling in the making and maintenance of roads. This machine is carried wholly upon two long rollers, each one extending the full width of the machine, and both driven by the engine; and the steering is effected by sliding the axles at one end so as to throw them out of parallel when traversing curves.

The three-roller principle has been successfully carried out by Messrs. Aveling and Porter, in combination with their steam traction engine, with which the successful experience of many years' working had been previously obtained; and a number of steam road rollers of this make are now in use both in this country and abroad, having been at work from one to two and a-half years.

This machine is shown in Figs. 1 to 5, Plate 363. The two side rollers A A are driven by the engine and connected to the same axle B, and the centre roller C is made in two portions, turning separately upon their axle for facility in steering, and carried in a turntable frame D for steering. Each portion of the centre roller is the same width as one of the side rollers, and the centre roller overlaps the side ones to a small extent. The total weight of the machine is distributed equally upon the two axles, so as to equalise the action of the rollers in working.

A single steam cylinder E is employed for driving, as in the traction engines, for the sake of simplicity and economy of construction; and with the use of intermediate gearing reducing the speed considerably, and a fly-wheel F upon the crank shaft for turning the engine by hand over the dead points when requisite at starting, the single cylinder has been found sufficient both in the road rollers and the traction engines. It is fixed on the front end of the boiler, surrounded by a steam jacket in direct communication with the boiler, as shown in Fig. 5, and having a dome on the top from which the steam is taken into the cylinder. The use of steam pipes is thus avoided, and priming upon steep gradients is prevented. From the crank shaft the motion is taken by spur gearing to a countershaft G carrying at its end the pitch-chain pinion; the bearings of this shaft are carried in curved slots H, Fig. 2, formed in the supporting brackets, so that the shaft can be raised when required in order to tighten up the slack that usually occurs in a pitch chain after some time of wear. The chain is covered up by a wrought-iron casing, and drives the chain wheel K, which is keyed upon the front axle B of the machine; the two driving rollers A are not keyed upon the axle, but are secured to it by the strong locking bolts I I, Fig 5.

The turntable D, Figs. 2 and 3, carrying the centre steering roller C, is constructed with only two vertical carrying wheels J J, placed fore and aft, which allow it to swivel vertically to a slight extent, for the purpose of letting the rollers accommodate themselves to the convex surface of the road. The set of horizontal friction wheels L L guide the turntable horizontally in steering; and the machine is steered by a chain passing round the turntable, and worked by worm gearing from a handwheel M in reach of the steersman upon the footplate. The machine can be turned round by this means in a distance little more than its own length; and it can be turned within its own length, if required, by disconnecting either of the two driving rollers A A, which is done by withdrawing the locking bolt I that couples the roller A to the driving axle B, as shown in Fig. 5. A friction break, consisting of a wrought-iron strap upon a pulley N on the side of one of the driving rollers, and worked by a worm and screw P from the footplate, affords control over the machine in case any of the gearing should give way. The boiler is horizontal and multitubular, placed longitudinally between the two driving rollers; the coal bunker and water tanks are placed at the sides of the firebox, containing a supply of coal and water sufficing for two hours' work.

The ordinary size of this road roller, such as is shown in the drawings, weighs 15 tons; and the total width over the rollers being six feet, this gives a compressing load of two and a-half tons per foot width upon the road: the rollers are all five feet diameter, and the load is distributed nearly uniformly over them all. There are thirteen of these 15-ton machines now at work, several being in India and in the United States. Single machines have also been made of 20, 25, and 30 tons weight, which roll widths of 7, 8, and 9 feet respectively; the 25 ton roller has been working two years at Sheffield, and the 30 ton roller two and a-half years at Liverpool. This 30 ton roller is 9½ ft. total width, giving a compressing load in rolling of 3 tons per foot width; the steering roller is 5ft. diameter, and the two driving rollers 7ft.

The average cost of working the 15-ton rollers, under the ordinary conditions of this country, has been found, from a number of different trials, to be as follows, taking the actual cost of working, and adding an allowance for wear and tear and interest, but not including general superintendence charges, nor cost of water used. The daily working expenses amount to—

	s.	d.	s.	d.
Wages to engine-driver, 5s.; steersman, 3s.	8	0		
Coke, 4½cwts. at 1s.	4	6		
Oil and cotton waste	2	0		
			14	6
Allowance for wear and tear at 10 per cent., and interest at 5 per cent., on the cost of the roller £550, taking 250 working days in the year			6	7
Total cost per day			21	1

There has not yet been a sufficient length of experience in the working of these steam rollers for determining accurately the cost of wear and tear, but the above estimate is based upon the long experience that has been obtained with the traction engines.

The average work done per day is 2,376 square yards rolled complete; and with the above total cost of working—21s. per day—the work amounts to 9½ square yards rolled for one penny, including wear and tear and interest; or 13½ square yards rolled for one penny, for wages and fuel alone. Taking only 2,000 square yards for the day's work, this gives 11½ square yards rolled for one penny of working expenses; or eight square yards for one penny, allowing for wear and tear and interest. These results are confirmed by those obtained in the working of two of the same rollers in India, where the cost of working has amounted to 43s. per day for each machine in rolling a space of 7,040 square yards, which gives 13½ square yards rolled for one penny, the same as in the previous statement.

The practice of leaving the metalling of roads to be consolidated only by the traffic passing over them has been so universal in this country, that rolling the roads whether by horses or by steam power, is still generally looked upon rather as a refinement than as a source of economy in road maintenance. On the Continent, however, experience has led the French and Germans to consider rolling as the most important improvement ever made in the construction and maintenance of roads. The absence of any centralised authority in the road administration of this country, such as is customary on the Continent, has been unfavourable to the adoption of rolling here.

Road making is also subject to so many varying influences in the nature of the traffic, the locality, the quality of the metalling, the construction of the road, and the method of maintenance, that it is difficult to arrive at the exact amount of the economy resulting from rolling as compared with the absence of rolling; but from an average of extended experience in different countries, the economy attending the practice of rolling, even when horse rollers only are employed, is found to amount to as much as 34 per cent. saving, in cost of metalling alone. Rolling prevents the metalling from being crushed piecemeal by the traffic, as is done when it is laid down loose without rolling; and the entire road is rendered better able to resist the injuries caused by moisture soaking in. A saving in labour in the construction or repair of a road is also effected by rolling, as the rolling allows of a greater area of metalling being laid down at a time, and a thicker coating of it when requisite; and instead of the stones being thrown down in small patches wherever defects show themselves in the road surface in course of time, the maintenance of the road can be carried out in a systematic manner. The force of draught required upon freshly laid unrolled metalling is as much as five times the draught for the same load upon a fairly good road surface, as ascertained by old established experiments; and this great difference shows the important saving which the users of a road derive from the adoption of rolling. This increase of draught also involves increased injury to a road from the horses' feet; so that in the ordinary case of rolling down a road by the action of the wheel traffic, this is not done, as commonly supposed, without cost to the maintainers of the road. On a well-rolled road, however, the wear that takes place is mainly that due to friction, as the vehicles passing over it are not jolted about with a continued series of concussions on the road surface, while the horses have less force of draught to exert, and the metalling is not crushed to pieces.

The drawbacks attending horse rolling are, however, very great, especially in the case of a road with heavy traffic. The rolling interferes with the passage of vehicles, on account of the long string of horses required to drag the roller, and the consequent trouble and delay of turning round at the ends of the course; and the horses' feet disturb the metalling in a way that cannot be corrected by the succeeding passage of the roller. To roll a road completely with such a light weight as only a six-ton or even a ten-ton roller, which is the heaviest possible horse roller, it requires to be gone over a great number of times; and this weight of roller is much below that of the traffic in large towns, when calculated by the same measure of tons weight per foot width of the waggon wheels.

With the steam roller, however, all these objections are overcome, on account of its greater weight and the greater facility with which it is managed, it consolidates the metalling with much greater rapidity, and can be easily turned round, and worked up steep inclines; and it has been shown by experience in Paris that under proper management it can be worked without passing horses being frightened. As to the relative expense, the same work can be done by a steam roller at less than one half the cost of horse rolling; while in cost of metalling a considerable further saving is effected beyond that realised with horse rollers. In Paris the steam-rolled roads are found to last twice as long as those rolled by horses; and roads which formerly had to be rolled by steam power once every six months, and previously much oftener by horses, have been so much improved by this operation upon the successive layers that they now require rolling only once a year. This result has occurred, too, under a traffic that is annually increasing; and as the centre of the heaviest traffic in Paris is macadamised, and not paved as in London, the experience there obtained evidently affords a sound basis for comparison with the streets of the large towns in this country. Rolling has proved of great service not only for surface repairs, but also for consolidating the foundations in making new roads; and in Germany the horse roller is very generally used also for setting paving stones, instead of using the hand rammer.

CAPTAIN TYLER'S REPORT ON THE FESTINIOG RAILWAY.

The following interesting report has been forwarded to the Board of Trade by Captain H. W. Tyler, R.E., giving the results of his examination of the experiments lately carried out on this narrow gauge line:—

"1, Whitehall, 4th March, 1870.

"Sir,—I have now the honour to report, for the information of the Board of Trade, that, in compliance with the instructions in your minute of the 8th ult., I attended certain experiments on the 11th, 12th, 14th, and 15th ult., on the Festiniog and Mid-Wales Railways.

"The object of these experiments was to test the capabilities of the Festiniog Railway, which has a gauge of rather less than 2ft., and also the powers and comparative steadiness of double bogie engines, such as have been designed by Mr. Fairlie, both on the Festiniog Railway and on the ordinary gauge of 4ft. 8½in.

"The trials were made in the presence of various members of an Imperial Commission, under the presidency of Count Alexis Bobrinskey, who visited England for these special purposes, as well as of his Grace the Duke of Sutherland, and numerous others from various countries, including Major-General Sir William Baker, R.E., and Mr. Thornton and Mr. Julian Danvers from the India Office.

"I beg to enclose herewith detailed statements of the experiments, in the form of the original documents, drawn up by myself in the presence of those who witnessed them, and containing descriptions of the engines employed.

"As regards the Festiniog Railway, they quite bore out what I stated in regard to it in my reports to the Board of Trade six or seven years since, previously to its being opened for passenger traffic, and those contained in a paper which I subsequently read at the Institution of Civil Engineers. The amount of traffic which can be economically carried upon this little railway, and the speed at which it can be conveyed round curves which would be absolutely impracticable under the ordinary system of railway working render it a most instructive example, showing how, by a reduction of gauge, adaptation of rolling stock, and judicious arrangements cheap railways on narrower gauges may be advantageously constructed in our colonies, in foreign countries, and even in parts of the United Kingdom. The precise gauge in such cases should, however, be suited to the local circumstances of each particular locality, and must depend upon various considerations which it is not necessary here to detail.

"When the Festiniog Railway was first opened for passenger traffic the Board of Trade, on my recommendation, made it a condition that the speed should be limited to ten or twelve miles an hour. And this was done on account of the narrowness and lowness of the works, the condition of the permanent way, and the novelty of the system of applying locomotive power to so narrow a gauge. Since that time the permanent way has been materially improved, and the greater part of it has been relaid with heavier rails, fished at the joints. The system has also been thoroughly tested, and there appear to have been no accidents to passengers. But the narrowness and lowness of the works remain, and this is now the weak point of the line.

"At certain bridges on the lines and other places, extra height and width might, apparently, without much difficulty or expense, be afforded, and the company would do wisely in making such improvements as far as practicable; but the enlargement of the tunnels and of the width in certain other places would, no doubt, be very costly.

"The speed appears to have been increased from time to time as the permanent way has been improved, and it would now, I think, be only right to release the company from the obligation which was imposed upon them in this respect on their first opening for passengers. As they have hitherto conducted the traffic with safety to the public for so many years, the question of speed might now properly be left to their own discretion, not with the idea that they are to run their passenger trains at the comparatively high speed of which the little line has so curiously shown itself to be capable, under the system of low centres of gravity, which has so wisely been adopted for the rolling stock, but with confidence that they will keep well within that speed, and allow ample margin for all contingencies, such as cannot always be foreseen even under the most careful management.

"As regards Mr. Fairlie's double-bogie engines, the experiments have shown, not only that the principle upon which they are designed—first, of reducing wear and tear and friction by the employment of the bogie system; secondly, of conveniently accumulating the weight upon the wheels, so as to make all the wheels into driving wheels; and, thirdly, of providing engines which can run in either direction with equal safety—are sound, but also that the narrower the gauge the more profitably they can be employed for through traffic.—I have, &c.

"(Signed) "H. W. Tyler."

PATENT LAW.

The Bovill Litigation.

(*Continued from page* 152.)

We have now to give the judgment pronounced by Lord Cairns on 7th December, 1868, in the case of Bovill *v.* Smith, prefacing it, however, with extracts from the evidence of Mr. Bramwell, so frequently referred to in the judgment.

Mr. Bramwell said in the 5th paragraph of his affidavit—

"I say that I, reading the plaintiff's specification of 1849 as an instruction to a mechanic, understand that the second claim of invention therein stated, is for that which for many years such invention was understood to mean—namely, a combination of the blast from a fan or other blowing machine, with an exhaust apparatus to take away the plenum of air, blown in and forced through the stones by that blowing machine, and I say that the language of the plaintiff's specification is clear and well calculated, and sufficient to instruct a workman that when he is working millstones, not in the ordinary manner, without wind, but with the blast of air produced by a fan, or some other blowing machine, he is to apply an exhaust to take away the warm dusty air forced by such blowing machine between the grinding surfaces.

"I say that I, as an experienced mechanic, reading the specification of the plaintiff's patent of 1849, and being instructed and warned thereby, should not have understood or supposed that in constructing or using such apparatus and arrangements as I saw at the defendant's mill, I should be in any way imitating any of the matters which the plaintiff claims therein to be of his invention, for as regards the first of these matters, I say that the defendant does not, so far as I observed, and I believe he did not introduce air pipes into the top millstone, so as to more freely ventilate the grinding surfaces when currents of air are forced or exhausted through them, and besides this, the top stones in the defendant's mill are the running stones, and are not fixed; and as regards the second of these matters, I say that the defendant does not work his millstones with a blast of air, but does work his millstones without wind, in the ordinary manner, as mentioned in page 3, line 1 of the plaintiff's said specification of 1849, as printed after the disclaimer. And as regards the third of these matters, I say that the defendant does not strain the stive or air surcharged with fine flour through suitable or any porous fabrics, but blows the same out into the external air.

"I say that I observe at paragraph 40, 42, and 48 of the plaintiff's bill of complaint that the plaintiff in effect states the second part of his invention (that relating to the exhaust) to embrace cases where an exhaust fan is applied to millstone cases, regulated so as to carry off what is termed in the bill the plenum of air, although there be no fan or other blowing machine applied to such millstones, and that to support this statement, he, in the 10th, and several other paragraphs, alleges that the revolving millstone itself is such a blowing machine as was intended by his specification, and I say that if these contentious of the plaintiff be correct, then his specification is calculated to mislead a mechanic, and is not sufficient to inform him where he is trenching on the plaintiff's alleged invention, for I say that a mechanic, reading the said specification, and finding there the statement that the plaintiff's invention consists 'in exhausting the air from the cases of millstones, combined with the application of a blast to the grinding surfaces,' and also finding there, in reference to the same invention, the words 'In carrying out the second part of my invention, when working millstones with a blast of air, I introduce a pipe to the millstone case from a fan or other exhausting machine, so as to carry off all the warm dusty air, blown through between the stones to a chamber,' would not understand that such words intended a blast of air produced by the mere revolution of the stones, because if this were the meaning of that passage the words, 'when working millstones with a blast of air,' would be not only unnecessary, but would mislead' since it is, according to the plaintiff's present contention, impossible to work millstones without a blast of air, whilst on the other hand, if it be possible to work millstones without a blast of air (and which is the mode of working a mechanic would understand by the above-quoted expression from line 1 of page 3 of the plaintiff's said specification), there is no direction anywhere given how to apply the exhaust when working in that manner.

"I further say, that if the plaintiff be correct in his contention that the second part of his patented invention includes those cases in which an exhaust is used without a blowing fan or some other machine, to force air between the millstones, then such invention was not new in the year 1849, for it appears on the face of this specification of 1849, that before its date an exhaust from the millstone case had been used, and the specification under the plaintiff's English patent of 1846, describe and shows in figure 7, on the sheet of drawings attached to it, a regulated exhaust, made to carry the air and the stive in one directon, while the meal is allowed to leave the stones in another direction, and I say that the regulating valves shown in this figure 7 were intended, and would be sufficient to place the amount of air carried away by the exhaust completely within the control of the workman. In the specification of the plaintiff's Scotch patent of 1846, there is on sheet A a drawing of a pair of millstones, showing the application of the blast, and this is accompanied by a description in the specification. There can be no doubt whatever that these stones were to have meal spouts, open in the ordinary manner, there being no directions whatever as to the spouts. The specification then goes on to state how, in lieu of the blast, an exhausting apparatus may be applied to the millstone hoop, and it states that in such cases the patentee dispenses with the air pipe L, (which is the pipe which admitted the blast of air from a blowing machine under the first mode of working), and the cast iron plate G (which covers the top opening of the hoop), in other respects, the arrangements are to be the same as the drawing. There is, therefore, no direction given as to altering the meal spouts, and therefore the result of putting an exhaust apparatus to work, according to the directions given in this specification, would be that the meal would go down an open meal spout, whilst the stive and air alone would go through the exhausting machine.

"I observe in the 17th and following paragraphs of the plaintiff's bill in this cause, he sets forth the advantage arising from the use of his patent at the Government mills at Deptford, and I say that I am intimately acquainted with the machinery at those mills, having superintended the erection of the earliest portion of it, and having seen such machinery some years afterwards, and having also seen the same on the 4th day of February, 1867, and I say that the machinery in use at the said Government mills is so far as regards the employment of a blast of air to the closed eye of the upper stone, and an exhaust from the millstone case in combination with such blast, similar to that which is described by the said Cabanes as hereinbefore stated, and that the defendant's machinery does not resemble the machinery so in use at the said Government mills, as the defendant does not employ any such blast, and I say that the advantages obtained at the said Government mills were obtained by machinery working with that combination, and that they were not obtained by the use of an exhaust unconnected with a blast; and I believe that an exhaust unconnected with a blast has never been, and is not now worked in those mills, but that the combination of a blowing fan and an exhaust fan has always been and is still used there. I think it highly improbable that the use of the blowing fan should ever have been discontinued, as it is undoubtedly owing to the action of this blowing fan, and not to that of the exhaust fan, that the large extra amount ground by each pair of stones is due, and I say this from my knowlenge of the results obtained by the use of the blast, under the plaintiff's patent of 1846, when uncombined with the use of an exhaust. The reason of the extra amount of work done by the blast becomes manifest, when it is considered that there are arrangements by which the blast can be and is maintained in the eye of the millstone at a pressure considerably exceeding that of the atmosphere, and that thereby the air had to escape, and does escape with force between the grinding surfaces, driving before it the flour, as soon as any portion of it has been formed from the grain. And I say that this beneficial action of the blast, in increasing the amount ground, is clearly pointed out at lines 15 to 32 on the third page of the printed copy of the plaintiff's specification, under his English patent of 1846, and is again stated in the first claim to that patent, and that the real use intention and object of the exhaust as used at the said Government mills, was, and is the carrying off of the plenum of air blown through between the grinding surfaces by the blowing fan, and which plenum of air without such exhaust would be an intolerable nuisance in the mill, as in fact it was when the blast under the Plaintiff's English patent of 1846 was applied, aud worked there in my presence without an exhaust.

(To be continued).

OPENING OF THE VICTORIA EMBANKMENT.

At last, after more thau eight long, weary years, aud an expenditure of more than a million and a-half, the Thames, or rather the Victoria, Embankment has been formally opened. The opeuing ceremony was not very grand, but perhaps eveu the Board of Works may, coutrary to the dictum of Sydney Smith, have had some slight consciousuess of their shortcomings, and consequently forebore on this occasion to add insult to injury. We have been much amused with the numerous grandiloqueut accouuts that have been giveu to the public respecting the magnitude and difficulty of the work, which appear to place it almost on a par with the Suez Canal. Certainly if we consider the time respectively occupied iu carrying out the two works there is not so much difference, for although the Suez Canal was begun somewhat sooner, is may be said to be finished, whereas the completion of the Victoria Embankment is a consummation that may be hoped for, but can scarcely be calculated upon. Until the new street between Blackfriars Bridge and the Mansion House is completed, the Embankment will be of but little practical use. While in its present state it can scarcely be called oruamental.

By means of the Embankment, 37¼ acres of foreshore have been redeemed, of which amount, the roadway with its approaches occupies 19 acres, and of the remaining 18¼ acres, only 8 are appropriated for public use. The only means by which carriages can at present obtaiu access to the road is by the two ends; but it is intended to open up six different approaches throughout its mile and a quarter of leugth, viz. :—Whitehall-place, Villiers-street, Waterloo Bridge, Norfolk-street, Surrey-street, and Arundel-street. The Whitehall-place approach is so far advanced as only to require metalling.

The roadway is 100ft. in width throughout, the footpath on the river side being 20ft. in breadth, and that on the opposite side 16ft. It is intended that the riverside pavement shall be edged by a row of trees throughout its entire length; and already the distance between Westminster and the Temple is, with the exception of a few gaps, planted with plane trees, placed 20ft. apart. The river wall is a beautiful piece of granite work, though we were sorry to see that two of the stones of the block piers had, by some meaus, been crushed so badly as to require to be replaced. The appearauce of the Embankment even now is very imposing, and it would doubtless constitute an excellent promenade to a "nigger" deprived of his olfactory nerves; but at present it is so insufferably hot and so peculiarly odoriferous that a walk from oue end to the other is not easily forgotten.

According to the official description of the Victoria Embankment, the following are some of the statistics, viz.:—

Excavation, 144,000 cube yards; Earth filling, 1,000,000 cube yards; Timber in dams, &c., 500,000 cube feet; Caissons, 2,500 tons; Concrete, 140,000 cube yards; Brickwork, 80,000 cube yards; Granite, 650,000 cubic feet; Paving, 125,000 superficial feet; Broken granite for road, 50,000 superficial yards.

The total cost of the work has been about £1,260,000; the amount paid for compensation, £450,000.

THE WORKING-MENS' INTERNATIONAL EXHIBITION.

An exhibition professing to be entirely composed of various productions of the industry aud genius of working-meu, popularly so called, was opened by H.R.H. the Prince of Wales on the 16th ult., at the Agricultural Hall, Islington. We cannot assert that these professions have been strictly carried out, as many of the exhibits are evidently not the production of working men, properly so-called; nevertheless, as the great majority fairly come under that denomination, it would be ungracious to find fault with the management on that account.

A large proportion of the exhibits are beyond the scope of our criticism; we cannot, however, pass over a figure of a boy reading, in the Italian department, which, if original, is evidently the work of a genius. It is also impossible not to notice an enormous collection of paintings, or rather copies of paintings, which are hung round the gallery, but we find it equally impossible to praise them; as, however, the name of the exhibitor had the addition of "Esq." attached to it, we presume they were only hung there to enliven the scene. In eugineering, it is to be regretted that there was so little of uovelty to be noticed, and so far as we could discover, but little of that novelty to be praised. In steam engines, the great idea appeared to be the working of oscillating engiues without an eccentric—an idea that has fasciuated most of us during our apprenticeship. We should have thought, however, that at the present day working men would have sufficiently understood the disadvantage of having no lead or lap to the valve to have exercised their ingenuity iu some other direction. One of these engines, however, has been constructed by an apprentice, and we will therefore willingly overlook the valve motion, and accord to it the praise it has fairly earned, both as regards desigu and workmanship.

For really first-class work there was nothing at all approaching to that shown by the workmen of the Midland Railway Company's shops. In this exhibit, several different parts of a locomotive were shown in various stages of completion; some being entirely black, some partly finished, and others entirely finished. The finished work was certainly most beautiful to look at, and apparently as near perfection as could well be imagined. We were, however, quite as much enamoured with the black work—in fact, we never remember seeing better or cleaner specimens of forging than were there exhibited.

The Agricultural Hall was uot nearly filled when we visited it; but as a great many of the exhibits, especially in the foreign departments, had not arrived, it will doubtless be much more interesting when complete.

THE CHASSEPOT AND THE NEEDLE-GUN.

The "Zündnadelgewehr," or needle-gun of the Prussian service, to which the victories of the Prussian arms in 1866 have been attributed, appears to have been originally patented in England as a muzzle loader in 1831, by a Mr. Moser, of Kennington. The invention came before its time; its cold reception in England drove the patentee to seek foreign patronage for his novelty, and Prussia was lucky enough to appreciate and adopt the new weapon. Dreysa, a gunmaker of Sommala, applied the breech-loading principle to Moser's patent, and, thus amended, the arm, ten years later, was, in 1848, introduced into the Prussian service. The principle, briefly stated, is the driving of a pointed pistou or "needle," by the action of a spiral spring (such as is used in the manufacture of children's toy guns) into a small case of fulminate, contained in, and situated between, the powder aud the bullet of a single cartridge. In the action of opening the breech, the spiral spring is set by the trigger; and thus the trigger, when pulled, releases into operation this spiral spring; which, in its turn, forces the needle into the cartridge and fires the piece. Upon this oldest form of the Prussian needle-gun improvements have been made, the chief effects of which have been a reduction of the mechanism of the needle of 1848, and a general lightening of the eutire piece. None of these alterations, however, have touched these two apparent evils in the old form of this arm which militated against its adoption by England in 1850. These are, the positiou of the fulminate iu the interior of the cartridge, and the looseuess of mechanism, involving possibility of the escape of gas, round the needle and at the base of the plunger.

To these two particular points France maiuly devoted herself in seeking a superior needle rifle to that of Prussia. In the Chassepot such an improved arm has been found. A triple wad of vulcanised india-rubber placed round the axis of its plunger, and forming with a steel plate a cushion to receive the force of the rebound, is intended to render the breech gas-tight, but has been found in practice only partially adapted to that object. An iugenious arrangement of notches on the outer guider of iron, enables the gun to be placed at half-cock. The needle is lighter and smaller than in the Prussian gun, and above all, the cartridge contains its fulminate at the base of the powder, instead of at the base of the bullet. A vacuum, left when the gun is charged, between the base of the cartridge and the front of the plunger, is to effect the combustion and removal of any portion of the cartridge-case that may remain after firing. As compared with the Prussian gun, this weapon possesses, besides the specific improvements mentioned, other advantages of superior manufacture and finish Its cartridge, besides admitting the altogether different principle of firing, contains a larger charge of powder than the Prussian cartridge, with a smaller bullet, which leaves a manifest advantage in carrying to the French weapon; while the fact that the Prussian bullet is purposely made so small as not to touch the barrel in its passage, while the French bullet is of the ordinary size to fit the rifle barrel, would point to the conclusion that the Prussian marksman is at a disadvantage over the Frenchman in respect to his aim. The number of times of firing per minute is aboout the same in both cases. The cost of the French weapon considerably exceeds that of the Prussian, and the Chassepot is, in addition, a more difficult gun to make.

To all the comparative information which has been published about the French and Prussian guns, must be added the following from the *Journal du People*:—

"At 500 metres the Prussian weapon gives only negative results; whilst at 1,000 the Chassepot, in the hands of good marksmen, hits the target with great force. We call attention to this point, for, in the war of large bodies of sharpshooters (the only system which we ought to adopt), an arm which is not reliable over 500 metres cannot reach the reserves of the first front, which escapes the effect of the enemy's fire. The drawbacks of large bullets have been noticed, the principal being this, that, with needle-guns, the firing is rapid, and, therefore, a great amount of powder is burnt; consequently, the cartridge-box must be well stored. Now, there is in the weight of ammunition allotted to a foot soldier a total which cannot be exceeded—namely, ten pounds. What will happen? With that weight of cartridges, the Frenchman will have twice as many shots to fire as the Prussian. Nothing is more difficult than to replace, during fire, the ammunition by a fresh distribution. Thus, the retreat of a division may depend on its finding itself in face of an enemy which had still 20 or 30 cartridges a-head to fire It will be seen that the winning of a battle may depend on the projectile adopted."

THE BRITISH ASSOCIATION OF GAS MANAGERS.

ADDRESS.

By Mr. Magnus Ohren, V.P.

(*Continued from page 155*).

The next paper is by Mr. T. H. Methven, of Bury St. Edmonds, on "Tar Pavements." We all long for the luxury of tar pavements along our country roads, and I make no doubt the system would be largely adopted if the material could be made hard and durable, so as to save us, in summer weather, from sticking to the pavement, like flies in treacle. I hope that Mr. Methven's system is satisfactory on this point; for myself, I consider it necessary to boil the tar, to get off the light oils and water, otherwise the material will not set firmly, or at least until the sun has done the work that should have been done previously; if, then, it becomes necessary to remove the light oils, I consider they should be removed by distillation and utilised instead of being boiled off in the open air, to the great nuisance of the neighbourhood where the operation is performed: for remember in those oils which would be lost in open boiling, we have benzole, &c., from which analine is made—the base of those beautiful colours, magenta, and mauve—so fully reported upon at the last annual meeting by tho President for that session, Mr. Goddard.

Mr. W. T. Feavtrell gives us a paper connected with tar—on "Artificial Alizarine;" or, chemically speaking, on alizarine, artifically produced from a base obtained from coal tar oils called anthracene; this is, however, not made from the light oils before alluded to, but it is obtained from the last of the heavy oils, commonly called creosote, which comes over just previous to the tar becoming hard pitch.

While on the subject of tar, I may state that another important use that tar is likely to be put to is in the manufacture of gas. As tar contains a large quantity of rich hydrocarbons, it has engaged a large share of tho attention of gas engineers, who for many years have, by various means, endeavoured to convert the valuablo fluids which it contains into permanent gases. Their attempts, however, have not been attended with anything like success—principally because it was found that solid deposits and naphthaline caused obstructions in the mains and pipes, and carbon on the retorts, without the anticipated increased quantity of gas. An improvement has, however, been introduced at Cork by Messrs. Hill and Lane, and although the new process has been in operation over a year, no deposits have been observed in either the manufacturing or distributing apparatus.

The essential difference between their process, which, by the bye, they have patented, consists in the thorough amalgamation, by suitable machinery, of the tar with a portion of the coal which is to be carbonised. From 30 to 40 gallons of tar are mixed and ground up with ¾ of a ton of coal and ¼ of a ton of breeze; the proportion to be used is 25 per cent. of a total quantity of coal to be carbonised.

Tho advantages claimed for the process being a large yield of gas, increased illuminating power, and reconversions of breezo into coke, its particles being cemented together by the pitch of the tar. It is said that inferior Welsh coal treated under this patent can be made to yield 15 candle gas, tested by tho old London burner. The theory of the process appears to be this, that while in former experiments the tar was merely distilled, in this process it is in a great measure decomposed, and that the poorer gases coming from the coal while in their nascent state, combined with the rich hydrocarbous of the tar which are thus converted into permanent gases, instead of condensing and forming obstructions in the apparatus. The patentees have given a long trial to the process before endeavouring to get it adopted by other companies. Some trials have been made in Dublin extending over several weeks, and these have resulted, it is reported, in considerable economy of manufacture. If further experience confirms these results, gas companies—particularly where the iron stoker is in use—will no doubt adopt the process, and as a consequence tar will rise in price as a great quantity will be withdrawn from sale. Gas managers will do well to bear this in mind in making their contracts for the sale of tar.

We have next a paper by Mr. D. Clarke, of the Gas Works, Brymbo, on "Stoppage in Ascension Pipes"—a capital subject to ventilate—and your attention should be closely given to this paper, and the views of each freely discussed. It is useless to have good retorts and good settings, if the gas does not pass freely from the retort as generated; the loss that occurs in many places while the so-called "jumping" process is being performed is most distressing to witness.

I hope Mr. Clarke will throw new light upon this subject. If he advocates large ascension pipes and capacious hydraulic main, not too close in contact with the retort beds, he will be in the right track; but I will not anticipate his views; I desire more to guide the discussion on the subject after the paper is read.

And the subject analogous to this, "The Scurfing of Retorts," is, I believe, to be brought forward by Mr. Cockey, who has an apparatus for securing retorts. Like the stoppage in ascension pipes, the deposit of carbon on the retort results from pressure, or the want of relieving tho retort from the gas as generated, and the aim of gas managers should be, not to devise apparatus to remove carbon, but to prevent the formation of it. It is a known fact that although a gas exhauster, working at level gauge draws off a considerable portion of the gas produced in a retort, still a pressure is maintained in tho retort equal to the seal of the dip pipe, and that, if that pressure is not removed, a large portion of gas is destroyed in the retort; this is particularly the case where through retorts are used, if the dip, and consequently the pressure, on one side is greater than on the other. About ten years ago I had experience of this fact, the sinking on one side of some through retorts caused an increase in the seal of the dip pipes on that side, consequently the whole of the gas generated passed off at the other side, the pressure there being lightest. To remedy this defect I invented an apparatus, which I called a movable disc, by which the liquor in the hydraulic main could be regulated, and the pressure equalised, allowing the gas to pass off at each end; when this was done the carbon ceased to accumulate on the retorts, and the make of gas and illuminating power was increased. If any gas manager finds himself in the same difficulty that I did, and would like to try the effect of the apparatus, I refer him to Mr. Sugg, of Westminster, who made tho apparatus for me, and has, no doubt, the pattern by him.

We have a paper by Mr. Goddard, of Ipswich, on the "Application of Gas to the Generation of Steam." Any application of gas to the uses of man must be a benefit to the gas producer as well as the gas consumer, and, therefore, the application of gas for the generation of steam, whether for machine power or for cooking, if effective, must cause an increase in the sale of gas. That gas can be used for cooking with advantage, is a fact known to many of us. Mr. Somerville, of Dublin, introduced cooking stoves at Maidstone, and so satisfied wero the consumers with the use of his stoves, that they were taken faster than he could make them, and his summer consumption of gas was largely increased thereby. I believe he has also introduced them at Dublin, and I have no doubt with good results; hitherto the great drawback to cooking stoves was the smell, but by using stoves made with glazed tiles and atmospheric burners, they give off no smell and can be fixed in any part of the house as they require no chimney; the benefit to be derived from the use of these stoves in small houses during the summer months is self-evident. From experiments made by me, I have found that the cost of gas for cooking a joint is very much less than coal, if the fire has to be made for that purpose only. These stoves have just been introduced to our consumers, they cost the company £5 5s. each, and we let them out at a rental of 2s. 6d. per quarter. I recommend gas managers to consider this subject to increase summer consumption.

Mr. W. J. Warner, of South Shields, will give us a paper "On Gas Meters." My own opinion respecting meters is that in the "Sanders and Donovan's" patent wet meter as now manufactured by the Gas Meter Company, we have a perfect wet meter, and I look for improvements in the dry meter. The best description of dry meter I have used is that commonly called "Croll and Glover's Meter," but there are still improvements to be made in it to insure accuracy of registration after having been at work for three or four years, and although those in error bear only a small percentage of the meters made we look for improvements to reduce even that small percentage of error which is very annoying to the company and the consumer when it does occur.

The measure of the illuminating power of the gas follows next. Mr Harley will read a Paper on Photometry. Mr. Warner's is an important subject, the measurement of gas, fairly and justly, between the company and the consumer, and of almost equal importance is the measurement or determination of its quality; for unless the system in either case be of such a nature as to insure accuracy of result, the relations between the seller and the buyer of gas can never stand on a satisfactory footing; hence any new system by which our measures may be improved, or any modification of the present system which appears to be an improvement, or is put forward as such, claims the attention of gas managers.

Among the novelties of Photometry is the apparatus designed by Mr. F. W. Hartley, of Westminster. The apparatus consists of three photometers converging to a common centre, which is occupied by one candle, so that three operators may determine the illuminating power of any one of three gases compared with one and the same candle; fortunately those days are passing away when two or more gas companies were allowed to supply gas in the same street, generally resulting in a waste of the shareholders' money, and a loss to the consumer, otherwise this photometer would have been useful to try one company's gas against another, but now I do not see the object to be obtained. I can understand three operators testing the gas at one time and then comparing their results. I believe they would be nearer the truth than three separate testings by a single burner, not that I put much faith in the report of difference in the human vision. I believe the difference to be in the candle not in the vision, and I am led to infer, if this be so, that Mr. Hartley's instrument would be more perfect if his gas was in the centre, and the candles placed at the three points. The difficulty that I have experienced most in photometry is the variation in the amount of light given by different sperm candles, and even different parts of the same candle, and under different temperatures, and I conceive that the more we multiply the candles the nearer we arrive at a correct average. Supposing, then, we have three pairs of candles—two at each point, by this means any variation in one pair of candles will be checked by the other two pairs, for, although not impossible, yet I think it hardly likely that all the candles would err in the same way; at any rate a certain number of experiments must necessarily end in a more perfect result than at present obtained with the single apparatus, and this fact I believe was maintained by Mr. Kirkham in a paper read by him at the Institution of Civil Engineers last year. A lecture is to be given by him and Mr. Wm. Sugg this evening on "Photometry as applied to the Estimation of the Value of Coal Gases," and, as a matter of course, the "Cross Photometer" will be exhibited and explained, so that with Mr. Hartley's paper and Messrs. Kirkham and Sugg's lectures, members will have a history of photometry to the present day, and will be able to judge the merits of each apparatus.

I find, connected with this subject, that we are to have a paper by Mr. Charles Heisch, the Gas Examiner to the Corporation of London, on "The Method of Testing the Illuminating Power of Gas, with special reference to Burners."

I take this opportunity to direct your attention to a report made to the Board of Trade by the referees appointed under the City of London Gas Act, 1868. One of the questions referred to the referees was to determine the burner to be employed in testing the gas for illuminating power. As appears from the report, the referees carefully examined the various kinds of burners in use, and also some new ones, and the result of their inquiries was the adoption of a burner submitted to them by Mr. William Sugg, now known as the "Sugg's New London Burner," in all respects a beautiful instrument, superior to any hitherto invented.

In the referees' report, the burners in use by the consumer are commented upon. How often has this subject been commented upon, and the unfortunate consumer, after trying burner after burner, drags on his life in a state of semi-darkness? He has gone past complaining, and has a belief that the fault is in the *gas*, not the burners, and that he is being victimised by the gas company.

It is therefore a matter of rejoicing to gas managers that the gas referees have probed this sore point—with a desire to heal it. Their inquiries revealed in an extraordinary manner the badness of the burners in common use; their investigations as detailed in their report, show that some of the burners give barely 20 per cent. of the real illuminating power, and on inspecting various large establishments, the burners in use gave only 55 per cent. of the illuminating power obtainable from the gas. These facts prove in a remarkable manner how groundless has been the bitter outcry on the part of the public against gas companies. They show that the fault has really lain with the consumers themselves, who have been in the habit of wasting the gas supplied to them and throwing away large sums annually, by the use of shamefully bad burners. This is a point of great importance to the public, and it is to be hoped that one result of the publicity given to this report by the Board of Trade will be to lead consumers to adopt better burners, a change which will be greatly in their own interest, and which ought certainly to lead to a cessation, or, if that be hopeless, at least a diminution of the outcry against the gas companies. At the same time let me point out to gas managers that it is their duty to assist consumers to a selection of burners. For years past I have done this, and we recommend Sugg's steatite burner and the slit fishtail as far preferable to the two-hole fishtail. In a paper read by Mr. Sugg at our last meeting, on burners, the Brönner burner was mentioned as giving an illuminating power of twelve candles with a consumption of 5ft. per hour. I have made some experiments with this burner, and am pleased with the results; these burners are all split or batwing burners, and glasses are made to suit that description of burner; they are made of various sizes, from 1 to 8ft. Mr. Greene, of King William-street, London-bridge, is the London agent for these burners, and they have given great satisfaction in places where they have been fixed. Mr. Sugg has also a new burner which contains in the socket a regulator; by this means you can with four sizes effect the same object as the Brönner burner with eight or nine sizes. A sample of both burners will be before you for inspection.

The last paper on my list is by Mr. Davis, introduced by Mr. E. White, of Birmingham, "On a new form of Gas Exhauster." The subject of gas exhausters was discussed in committee, and it was thought that a practical trial of the working of the various known exhausters should have ocular demonstration of the working. I think this was a step in the right direction. I am sorry the committee had not time to carry it out, but it may be borne in mind.

I believe I have now exhausted my stock of papers if I have not your patience—and I shall just glance at two or three new introductions in the shape of valves. Who is there so fortunate as not to have been plagued with leaky valves, and what mischief have they not caused? I hope next session we shall have a paper on valves, and I would draw attention to Messrs. C. and W. Walker's new patent for improvements in centre valves, "Cathels and Terrace's" patent four-way disc gas valves, Mr. George Livesey's water valve, Thorneloe and Co.'s patent flexible valves, C. and W. Walker's slide valves for large sizes. Messrs. Walker are manufacturing the centre valves for the Beckton Works. The centre valves hitherto made by them were liable to leak from settlements of naphthaline and dirt upon their surface facings. Some of these deposits were of a slippery nature, so that the valves in turning slid over them, instead of throwing them off, and became leaky. Messrs. Walker's improvement overcomes this difficulty by means of casting surfaced bars, or covering facings, in the valve, which do not interfere with the passage of the gas, but always cover the surfaced facings of the partitions of the body, thus protecting that part from injury of every kind, and rendering the valve perfectly tight. A gentleman will be in attendance with a model and drawings for the inspection of members; he will also exhibit a drawing of the new wedge valve. The valve itself is no longer a disc plate with a spring behind, but a rigid solid wedge of cast iron, having two perfectly-surfaced facings fitting the facings inside the body casting; it is worked by a powerful screw, and is said to be perfectly gas-tight. Messrs. Cathels and Terrace's are improvements on the well-known four-way gas valves, and consist of a simplified arrangement of the gas ways through the valve, reducing it in size and weight, the ports being now all on one level, the disc being actuated by one movement, instead of two, as formerly, and last, though not least, by the impossibility by this arrangement of accidentally shutting back the gas, because the closing of one gas way simultaneously opens another. The principle will be easily understood by an inspection of a model of the valve on the table. Mr. Livesey's water valve differs entirely from the old water valve; it is very simple, but, no doubt, very effective. It has no facing, springs, or wedges to get out of order, and is easily worked. I hope Mr. Livesey will have a drawing of it with him to explain it. I look upon it as a valuable invention. Messrs. Thorneloe's valve appears an adaptation of the principle of Morton's retort lid, and will, no doubt, do very well for small mains. I have much pleasure to inform you that Mr. Evans has invited the members to view the Beckton Works. A steamboat has been chartered to take the members there; the boat will leave Westminster pier at 10 o'clock, calling at Hungerford and London-bridge, and I am sure that any of our visitors will be welcomed if they should desire to accompany us. I may also state that one of our new members, Mr. George Payne, of the firm of Simpsons, Payne, and Co., has invited the members to view his sulphate works on their way down; the boat can run alongside his wharf at Millwall, and members can walk on to the works.

A few words in conclusion. I make no apology for the length of my address, feeling, as I do, that I have only touched upon those points which seemed to demand your attention and my recognition; and however dry to our visitors some of the subjects may be, they are all of importance to gas managers, whose duty and interest it is to perfect themselves in every department, to keep alive to all new inventions or improvements, so as to secure any benefits which may arise therefrom to their respective companies. If I have failed to condense the matter I have laid before you, that I grant is a fault, although, perhaps, a fault more honoured in the breach than the observance—for I would much rather repeat myself, than fail to convey to you my full meaning; but, under any circumstances, I cannot but express to you my thanks for the kind attention you have bestowed on my remarks. It leads me to hope that they have not been destitute of merit, and if so, I trust some little good may result from it.

ON SCRUBBERS.

By George Livesey.

It is of very little use going to "Clegg on Gas" for information on any modern invention introduced within the last 20 or 25 years. Newbigging gives the pith of Clegg's article on Scrubbers in one laconic sentence, which, after all, refers more to the mechanical filtering or separation of the tar than to the extraction of ammonia and other impurities.

Newbigging tells us, quoting from Clegg, that "for every 1,000ft. of gas produced in 24 hours, 1 cubic foot of wet scrubbing material is required," which is certainly rather vague. Let me here observe that I say nothing in disparagement of our late auditor's work; on the contrary, I am bound to speak very highly of the book he has published, as containing a mass of valuable and reliable information that will be of use to every manager.

An endeavour has been made to trace the first introduction of scrubbers, but without success. It seems probable that a Darwinian system of development, if not of natural selection, has been in operation. All the older gas men remember the tar filter, or breeze boxes as they were sometimes called, that were in use some 20 or 30 years ago. Vessels constructed like ordinary purifiers, but filled with coke or coarse breeze, through which the gas passed after leaving the condenser or washer, in order to arrest the lighter tar that would otherwise be carried forward into the purifiers, an object that was successfully attained by these means. The spent tan from the tan yards was sometimes used instead of the coke with a very good result.

This might be called a scrubbing process; but the origin of the term is obscure, so is the first use of water to absorb the ammonia, though it is more than probable that the ammonia manufacturers were the first to suggest its use. The transition from breeze boxes or tar filters to scrubbers was accomplished merely by increasing the depth, and allowing water to trickle through; but only a small quantity of water being required, the difficulty was to distribute it equally. To meet this, F. C. Hills, of Deptford, adapted the well known "Barker's mill" (one of which is now in the room) to the purpose, but even this ingenious contrivance was not sufficient of itself; it distributed the water equally, but the quantity required to keep it going made the resulting liquor too weak to be profitable. Hills then introduced a tumbler, as it was called—a sort of double trough, or an oblong pan or dish, with a division across its centre, and so balanced over an open box that the small stream of water alternately filled first one division and then the other, the division into which the water runs remaining in position until it is filled, when it is, so to speak, overbalanced, and tumbles over, emptying its contents into the box, and thus affording a sufficient quantity of water to cause the Barker's mill to turn for a minute or two, which stops when the supply is exhausted. In the meantime the other division is filling, and in its turn tumbles over, and gives another supply of water to the mill; a very small quantity of water was thus supplied at regular intervals, and distributed equally to the scrubber.

The Barker's mill is not much used now, though I decidedly consider it the best of all the distributors that have been invented, the chief difficulty arising from the small holes getting stopped, which was an almost daily occurrence; hence its disuse. The tumblor, also, is not often seen, though it did its work well, its only drawback being the periodical knock which it gave every time it fell, and the vibration thus produced rendered it difficult to prevent a constant leakage of water from the joints. It is more than twenty years since Hills introduced tho Barker's mill and tumbler; ammonia at that time was beginning to rise in value, and scrubbers for its extraction were being brought into use, thus superseding the original "washer," which had hitherto been used to remove the ammonia; it was effective for the purpose, but the drawback to its use when clay retorts were introduced was the pressure it gave. The scrubber, therefore, in modern gasworks does the work for which two separate contrivances were employed formerly.

The principle of the washer was the forcing of the gas through water, while the scrubber aims at bringing the gas into contact with water or a wetted surface without pressure. The liquor thus produced was at first not worth much; but to give an instance of its increase in value, about 1855, Laming (who had given a great deal of attention to this subject, and to whom the gas world is much indebted) offered the South Metropolitan Company £250 a year for their scrubber liquor; this was considered a liberal offer, and for ten years he had the said liquor for this sum. At the expiration of the first five years its value had much increased, but considering that in the first place the company was indebted to Laming for getting anything for this liquor, his contract was renewed for a second term of five years, by which time the scrubber liqour had about doubled in value after allowing for increase of make.

For a long time coke only was used for filling scrubbers. Hills recommended that it should have the breeze and dust separated, and that the large pieces should form the lowest layer of, say, a few feet in thickness, then a similar layer of smaller pieces, and so on, until the last layer was composed of pieces of about the size of walnuts. This plan involved a good deal of trouble, but it certainly was better than the indiscriminate throwing in of the coke, in that it was more effective, and did not get so soon choked with tar.

The other plan—as far as I can learn—that has been longest in use was the adoption of the Goldsworthy Gurney jet—jet of water under great pressure impinging on a small disc or button, which scatters the water as fine spray throughout the vessel, such vessel being empty, or at most having perhaps one or two tiers of perforated trays, the water thus descended in the form of rain through the gas. I am told this effectively removes the ammonia, but at some places where it is in use on asking what the liquor fetches, the reply has been that the liquor is not saleable, which means most probably that by this means of scrubbing the quantity of water required to remove the ammonia is so great that the resulting liquor is too weak for sale, the water descends too rapidly, and is not, therefore, in contact with the gas for a sufficiently long time. The object of putting anything in a scrubber is simply to retard and divide the water in its passage downwards.

I now proceed to describe some of the plans at present in successful use of charging or fitting up tho modern scrubber, and the various mothods adopted for distributing the water or liquor.

The following may be stated as the principles to be kept in view:—

1. That the gas should travel as slowly and freely as possible and therefore with the minimum of pressure or resistance.

2. That in its passage it should be brought into contact with the largest possible wetted surface.

3. That in order to comply with No. 1, the scrubbing material should occupy as little as possible of the space in the scrubbor.

4. That the scrubbing material should not be liable to get choked with tar and naphthaline, and consequently not require changing.

5. That in order to obtain strong liquor, the water should be distributed equally all over, and in very small quantity, this being also necessary to avoid impoverishing the gas.

The most common method of filling scrubbers at the present time is with coke, as above described. The chief objection I have to make against it is not as to its effectiveness for removing ammonia, but that it gets choked with tar, &c., and must therefore be emptied and refilled. At one large London works the scrubbers are changed twice a year; in my case they will go for about two years. There is one now in use, 15ft. 6in. diameter, and with only 40,000ft. an hour passing through it, gives between 4in. and 5in. pressure. The gas is thoroughly condensed, but as 500 gallons of liquor per hour have been passing through this vessel, a considerable quantity of tar has been deposited in the coke. At the City of London Works, where Mr. Mann has worked his scrubbers very successfully for many years, they require changing very seldom indeed; but he passes nothing through them but water. I have one other objection to coke, and that is that it occupies so much of the area or cubic contents of the vessel charged with it. If a vessel of 1,200 cubic feet contents is filled with coke, the interstitial space is 610ft., or say one half of the whole, the relative proportions will vary to some extent with the size of the pieces; but my experiment was with the coke in its ordinary state. This rule, of course, only applies when the coke in a scrubber is quite free from tar, &c., and when in that state the gas passes slowly and freely; but when the coke becomes choked to such an extent as to show its effects on tho pressure gauge, the interstitial space must be reduced very much, when the gas must pass very quickly, while the water or liquor probably flows down two or three small channels instead of gently working its way through the whole mass, as it does when the coke is clean. It therefore comes to this:—If the gas is thoroughly condensed and nothing but water is used, as at tho City Gas Works, coke answers the purpose admirably, and lasts for an indefinite time; but if tar to any extent comes in contact with it, either from imperfect condensation or where the gas is washed with liquor, which deposits its tar in the coke, the result will be that in a longer or shorter time the coke must be changed, which is a great nuisance.

At some places brickbats are used. The remarks about coke apply equally here; the bricks probably lie closer, and therefore in this respect are inferior to coke.

Broken pottery has been tried but did not succeed; it fills up too much of the space, and forms a succession of cups or dishes which catch and retain the tar and liquor.

Drain pipes of different forms and sizes have also been used with success; that form and arrangement which is found most useful is now in work at the Phœnix Gas Works at Vauxhall. Three layers of 2in. unglazed drain pipes are placed on each of the two trays; these pipes stand on end, and consequently offer no resistance to the passage of the gas, which is divided into a greater number of small streams, while the water or liquor is spread over a large surface, and I should think there could be no risk of this arrangement becoming choked. Boulders and pebbles are also used, and I believe answer very well, though they are difficult to get in many places, are very heavy, and take up much space.

There is just one other plan, which after much consideration of the subject I have adopted; I believe I was the first to try it. The circumstances that led to the idea were the difficulties and nuisance attending the use of coke. Something being wanted that should present the largest possible surface with the freest passage for the gas, and after experimenting with various things, and more especially different forms of drain tiles or pipes, and pottery, the arrangement of thin boards which I now exhibit was tried. A scrubber was fitted up in 1866 with them, which has been in use ever since, and to all appearances will go on continuously without risk or possibility of becoming choked. This arrangement presents a larger surface than any of the others; the material in a cubic foot occupies less space, and there can be no question about the freeness with which the gas passes, which is moreover divided into a vast number of such thin streams that with the rolling sort of motion that fluids assume caused by friction in passing over surfaces (somewhat rough as these are) every particle of the gas must be brought into contact with the wet surface of the boards over and over again.

To fit up a scrubber on this plan the wood required is as follows: the boards are cut from deals or planks 9in. or 11in. wide, 3in. thick, and with nine cuts dividing them into ten thin boards about $\frac{1}{4}$in. thick. The small upright blocks which are nailed between the boards to keep them a proper distance apart are 1in. × $\frac{1}{2}$in., while to keep each tier separate from those above and below it, and to serve also for sleepers or joists, I use pieces $1\frac{1}{2}$in. or 2in. square.

With this plan care must be taken to prevent the gas going up all in one place, and to attain this I fix a sort of inverted trough made of $1\frac{1}{4}$in. boards, which covers the inlet and extends across the bottom of the scrubber; the gas escapes from this trough through a number of small apertures in its sides, and is thus distributed with sufficient uniformity.

The fitting of the boards is now proceeded with, the first tier is laid on the bottom tier of sieves which used to carry the coke, and tier above tier is fitted, until the vessel is nearly half filled, a space is then left of about 2ft. 6in., when another succession of tiers is laid, which fill the remaining half, and on the top is placed coarse cocoa-nut matting to spread the water. I am now fitting up a scrubber 15ft. 6in. diameter and 28ft. high, in it will be placed 22 tiers of these boards, 258 in a tier, which will expose a surface of over 128,000 square feet, or within a trifle of 3 acres, and at the same time in each tier of 188 cubic feet the boards occupy not more than 60ft. to 65ft., thus leaving 120ft. for the passage of the gas, the boards, in fact, in the part filled by them, take up one-third of the space, leaving two-thirds for the gas.

But what is the result? My system of working is to pass the gas through three scrubbers. I happen to have four, and so use three, but find two are sufficient with this plan of fitting up. The first two are supplied with a large quantity of liquor, and the last with a small quantity of water; the greater part of the ammonia is absorbed by the liquor, which consists of that from the condenser, as well as that from the water scrubber (by this means it is increased in strength to 10 or 11oz.); the remaining ammonia is quite removed by the use of from 5 to 6 gallons of water in the last scrubber to the ton of coal, or hardly more than half a gallon to a 1,000ft. of gas. The liquor so produced being from 7oz. to 9oz. strength after passing through the wood scrubber, while the same vessel, filled with coke, required 3 or 4 gallons more water to the ton, and produced liquor of only 3oz. to 5oz. strength; the arrangement of thin boards is therefore about twice as good as the coke.

I have endeavoured to ascertain the average amount of surface exposed to the action of the gas when coke is used, but from its irregularities cannot arrive at it correctly, having been obliged to estimate in order to make a comparison with the surface exposed by other materials, such as drain pipes and boards. The result, as nearly as I can make out, is as follows, the only uncertainty being in respect to the coke:

Taking one cubic foot of the space occupied, I find

Coke gives about	$8\frac{1}{2}$	square feet of surface
3in. drain pipes	17	,, ,,
2in. ,,	21	,, ,,
Boards as above described	31	,, ,,

Coke occupies	$\frac{1}{2}$	the space
3in. drain pipes	$\frac{1}{3}$	,,
2in. ,,	$\frac{4}{9}$	,,
Boards	$\frac{1}{3}$	,,

Distributing apparatus. First, comes the Barker's mill, which was used for a number of years with varying success, but was liable to several objections, among them the holes being small, were often stopped up, and the machine would not revolve in consequence; then for lightness it was made of brass tube, which, under the action of ammonia, speedily corroded; but supposing these defects overcome, the instrument possesses great advantages, one being that if it can be kept going, it distributes the water or liquor very equally, and being self-acting all gearing or machinery is avoided. In the mill now in the room the danger of the holes stopping is avoided by making them larger, about $\frac{5}{16}$in. diameter (they are so arranged that each hole in its circle has to supply liquor to 20 square feet of surface). Corrosion is prevented by using a pipe, which lasts three or four years with liquor passing through it longer than with water. The mill works on a steel centre at the bottom, and at the top has a steel spindle working in a small hole in the top plate, while to see that it is at work a notch is cut in the top of this spindle, which takes hold of a corresponding projection on the end of another spindle, at the top of which is a ⊤, which, projecting above the scrubber, and revolving with the spreader shows whether the latter is working properly; instead of a gland a water joint is used, through which the spindle works without friction. The mill will work for from three to six months without any attention. At Exeter a Barker's mill of wrought-iron pipe with four arms, is found to answer the purpose admirably.

When water is used, the quantity being too small to turn the mill, an intermittent stream is needed, and instead of the scrubbing box a square or round vessel holding seven or eight gallons is fitted with a valve at the bottom, the spindle of the valve reaching to the top. A float slides on this spindle, which rises with the water, and when at the proper height lifts a weighted bell crank which, in its turn, lifts the valve. As the box empties itself the float sinks, and by its weight causes the loaded bell crank to return to its original position, thus closing the valve and shutting off the supply of water until the box is again filled.

The Gurney jet has already been mentioned. Fixed perforated arms of iron pipe require no description. They were commonly used, and are still in some places.

Another plan is with a series of troughs, arranged a short distance apart, and branching out on both sides of a large centre trough, such troughs being kept nearly full of liquor, and having a great number of notches cut in their edges, while in these notches are laid pieces of loose cotton or woollen material, the theory being that the liquor is sucked up by capillary attraction, and flows over in small quantities, falling in drops in the scrubber. This is a very pretty theory, but I very much doubt whether it will continue to work well. I should think that the capillary action would soon be stopped with the tar.

The ordinary revolving arms turned by machinery require very little notice, there being no necessity to take up time in going into detail. The difficulty has been with the small holes getting corroded, and to avoid this Mr. Trewby devised a system by which this inconvenince was entirely obviated. He used two spreaders revolving on their own centres, and the spreaders themselves also revolving in a circle half the diameter of the scrubber. The spreaders had each two arms, the liquor or water issuing only from the ends. The result was that by this double motion the water was distributed in a series of eccentric circles over the whole area of the scrubber. Theoretically, as much was discharged in the small area of the centre as in the larger area of the circumference; but practically it appears this inequality was of no perceptible importance.

This leads to Mr. Mann's invention—a model of which is in the room. He uses two spreaders like the last described, but they have fixed centres, and only one arm, the whole being moved by gearing. The water falls not directly on to the coke, but on a revolving circle of brushwood which catches the water and distributes it very equally over the coke. Somewhat more falls in the centre than at the outside; but Mr. Mann has by a very simple arrangement of a pair of eccentric wheels provided for a perfectly equal distribution if necessary, which can hardly be, seeing the success with which he works. His system, of which he has kindly given me particulars for this association, is to divide his gas between his five scrubbers about 12ft. diameter × 28ft. high, into each of which he passes a small quantity of water. It is supplied in the proportion of ten gallons to the ton of coal, and no liquor is pumped into his scrubbers, the result being that the whole of the ammonia is removed. On leaving the top tier of coke 8ft. deep the water has attained the strength of only $\frac{1}{2}$oz., which of course shows that the greater part of the ammonia has been extracted by the lower tiers, the second or middle one showing $2\frac{1}{2}$oz. strength, while from the third or bottom one the strength has increased to 14 or 15oz., which liquor mixing with that condensed brings up the whole to 10oz., of which he gets about 20 gallons to the ton of coal.

Mr. Mann now recommends six tiers, of 8ft. each, instead of three, believing that the highly concentrated liquor which would be produced would probably absorb a portion of the sulphur compounds which give so much trouble, and the increased height would require less water to absorb the ammonia.

I have also on the table a model, kindly lent by Mr. F. C. Hills, which if perfect regularity of distribution of the water is required, effects it with mathematical precision; the water runs into a circular revolving trough, divided into as many compartments as is thought necessary, and from these divisions, which vary in size, the water flows into a number of concentric troughs, which, revolving, supply equal quantities all over the surface of the coke or the rotating brushwood. It is a most ingenious contrivance, and would doubtless do the work admirably.

The uses of scrubbers are first to remove ammonia, which they will do perfectly; the ammonia, in its turn, absorbs a very large quantity of sulphuretted hydrogen, not less than half the total quantity. They have also been looked upon as the best and most hopeful means of reducing the sulphur compounds, and at the instance of the gas referees, who are engaged in investigating the sulphur question with a view to determine a maximum for this impurity, a number of experiments have recently been made, according to their instructions, in seven of the large gas works of the metropolis, with a view to ascertain the effect of scrubbing on the sulphur compounds other than sulphuretted hydrogen. The results of these experiments were most unexpected and extraordinary. Washing the gas with liquor has of late been looked to as the most hopeful means of reducing the quantity of these troublesome compounds of sulphur. But the above-mentioned experiments instituted by the referees appear to contradict this expectation; for out of the seven sets of experiments only two showed any good from scrubbing at all, the remaining five showing a greater quantity of sulphur compounds in the gas on leaving the scrubbers than on entering them. In consequence of the startling character of these results, the referees have instituted a further set of experiments of the same kind, as well as in regard to the effect of the purifiers, whether lime or oxide of iron. In these experiments, and generally in the important investigations which devolve on them, the referees have the willing assistance of the engineers of the various companies with whom they have to do. The experiments now instituted by the referees will take a very considerable time to execute, but they are calculated to render much service to the science of gas manufacture, and I hope to be able next year to lay before the society some further and more definite information on the subject.

The gas should always flow to meet the water or liquor, so that its last contact may be with the weakest liquor, or pure water. I mention this, because in some places an oblong scrubber is used with a division in the centre, the gas passing up one side meeting the water, and down the other, thus travelling with it; this half of the scrubber, when worked in this manner, is worse than useless.

As to the power of water to absorb ammonia, Dr. Odling, in this room, two years ago, showed by a beautiful experiment that pure ammonia gas was instantly absorbed, but when mixed with only 25 per cent. of another gas or air, a very long time elapsed before the absorption took place.

INSTITUTION OF NAVAL ARCHITECTS.

ON THE TREATMENT OF IRON MASTS BY SAILORS OF THE MERCHANT SERVICE.

By William Symington, Esq.

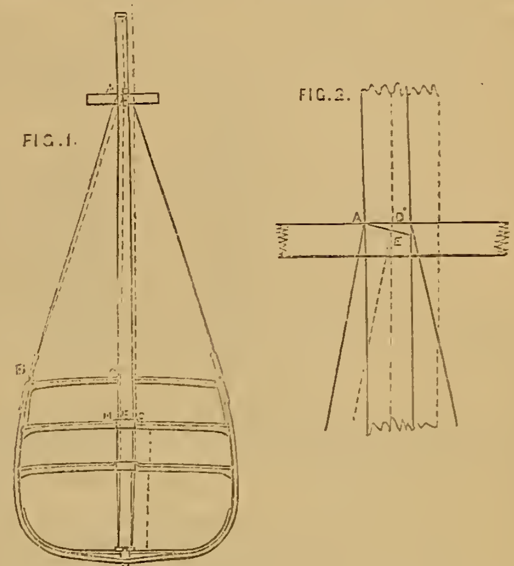
The drawings Figs. 1 and 2, represent a transverse section at the mainmast of a ship of about 1,600 tons register, with three decks. The mainmast is 90ft. long by 32in. diameter at the middle deck, and made of $\frac{7}{16}$in. iron plates, with three internal angle irons. It is wedged with pitch pine at the lower and middle decks as is the universal custom in the merchant service. It is likewise supported by six shrouds of 5in. wire rope on each side, the breaking strain of each shroud being 38 tons, and the Admiralty test 28 tons 6 cwt. Now, I think, I shall be able to prove that this mast must break, in consequence of the wedging at the middle deck, long before a strain of 10 tons can come on each shroud.

It is the usual practice, in London and Liverpool, to "set up" the rigging a short time previous to the ship leaving dock on an outward-bound voyage, and this work is generally done under contract by the riggers, under the nominal superintendence of the chief officer; I say nominal, because that officer is usually too much occupied with his cargo to be able to give the necessary attention to such an important matter; therefore the riggers are pretty much left to themselves.

The operation of "setting up" may be described thus:—A luff tackle and runner are generally applied to the lanyard, and a good strain is hove on the shroud—say to about five tons. When the shroud is considered sufficiently tight, a spun yarn "racking" or strand "nipper" is applied, to temporarily secure the lanyard, and the tackle is let go; immediately there is a considerable decrease of tension before the "nipper" or "racking" will bite; afterwards the end of the lanyard is secured above the dead-eye, the racking taken off the lanyard, and again there is a considerable decrease of strain, until finally there is usually less than two tons tension on the shroud of a 1,000 or 1,500 ton ship. If we consider that this work is done by contract, very often hurriedly and slovenly, it will be conceded, I think, by most sailors, that I have not mis-stated the amount of strain on the shroud of a 1,000 or 1,500 ton ship.

The vessel leaves the dock with the rigging thus "set up," and whatever may be the actual tension in tons on the shrouds, it appears to me no further, or at least a very limited, increase of strain can come on the rigging of an iron mast wedged at the decks, during any weather at sea, or however much the ship may roll.

Probably no one will deny that wire rope will stretch very considerably before being permanently injured. And here I would remark that I regret much being unable to furnish direct proof of the amount of stretching; still, I have given much attention to the subject, and made rude experiments, which enable me to say that a five-inch wire rope will stretch one foot in 100ft. with the greatest safety, and almost retain its original length.



In the drawing, I have considered the wind as blowing from the port or left-hand side with a force sufficient to throw the mast into the position of the dotted lines, presuming that it is not wedged. This deviation from the perpendicular may be measured by A D at the hounds equal to nine inches, and such a position would necessitate an increase of length of shroud equal to D E = 2·79in. and the length of F G at the middle deck is 2·61in.; so that in this particular instance, practically, we may say that as the shrouds stretch so will the increase of length almost equal the distance F G at the middle deck if the mast is not wedged at any deck. However, as it is so, it may be considered a rigid, inelastic, unyielding structure, with but an extremely limited room for displacement; and consequently I am at loss to conceive how any increase of strain can come on the shrouds, however much the pressure exerted by the wind in the direction of the arrow. If my statement of the tension on the shrouds at leaving dock is nearly correct, it will require but a very few tons more strain to stretch the rope 2·79in. and the consequence is, the mast is broken off by the first butt above the middle deck long before the rigging is subjected to half the Admiralty test proof of strain. Whereas, had there been no wedges, the mast would have been perfectly safe by the support of the rigging, and infinitely stronger than a wood one.

The fact that so few iron masts have given way is, to me, an incontestible proof that they are immeasurably stronger than wood ones. Let them be fairly and scientifically handled by sailors, and I venture to say that we shall hear no more of the loss of iron masts. If a wedging is desired, let it be made of massive india-rubber, or in a manner similar to the spring piston ring, so familiar to engineers, and then the masts will have play at the decks, and, as a consequence, the ship will be much easier under a press of canvas.

Marine surveyors usually tell us that "you will always find the first signs of weakness in a ship in the wake of the masts," and if you asked, "Why?" will reply, "Because of the strain on the rigging." With all respect and deference to their skill and experience, my opinion is, that if we take away the wedges at the masts, we shall get rid of most of the weakness now so easily observed there even in the best of ships. I believe the practice of wedging to be a barbarous and unscientific custom, as useless as it is injurious.

ON THE LAW OF RESISTANCE OF ARMOUR PLATES, COMPOSED OF ONE OR MORE THICKNESSES.

By Sir William Fairbairn, Bart., LL.D., F.R.S.

In my last paper, read before the Institution of Naval Architects, March, 1869, I endeavoured to establish the following laws of resistance of armour plates to a continuous statical pressure, analogous to that which is produced by the force of impact.

1. That the ultimate pressure varies as the product of the diameter of the punch by the thickness of the plate, that is,

$$P \propto 2rt$$

2. That the work requisite to perforate a plate varies as the squares of the thickness of the plate, multiplied by the diameter of the punch, that is,

$$U = Crt^2$$

where the constant C, in the case of statical pressure, by punching 10,010, and, in the case of flat-ended steel bolts, discharged from cannon, the constant

C=24,400, or about 2¼ times the value of the constant in the former case; and that this accumulated work lost, or expeuded uselessly, in the latter case, was due to some or all, of the following causes, viz. to the work expended in distorting the shot, to the shot breaking up a larger perforation than the uet diameter of the shot; to some other iujury done to the plate besides that of simple perforation; to the oscillations or recoil of the armour plate upon being struck by the shot; or to the want of directness in the line of impact.

3. That the ultimate pressures on the flat-ended punch, and on the rouuded-ended punch, requisite to perforate a given plate, are nearly the same; but that the work expended, in the former case, is considerably less than in the latter, and, heuce, it followed, that other things being the same, that the flat-ended punch, or flat-ended boit—in the case of guns—is more destructive than the round-ended punch or bolt, as the case may be.

In the present paper I purpose to show the advantages, if any, derived from having the plates (1) supported by an oak backing, and (2) from having double armour plates in the place of siugle solid ones. It will be seeu from the results of the experiments, that a great advantage is gained by the use of the oak backing, both as regards the ultimate pressure requisite to produce rupture, as well as the work expended in perforation. And, comparing the strength of the double plates with the single ones, under the same conditions, whilst the ultimate pressure in the former case is somewhat less than in the latter, yet the work of perforatiou expended on the double plates is greater than that expended in the single oues; so that it may be a question open to further experiment how far these results are borne out by experiments with ordnance. The experiments with the flat-ended and point-ended punches fully coufirm the law before fouud relative to the higher destructive powers of the flat-ended punch or bolt as the case may be.

Although it may be desirable that further experiments should be made on a large scale, yet it may be fairly stated that the labours of the Iron Plate Committee, during the four years of its sitting, were most praiseworthy, aud that the results obtained were most important both as regards the properties of armour plates as applied to ships of war and forts, and the strength and power of guns.

In the course of these experimeuts, the armour plates were first streugthened with a timber backing, then with irou, and, finally, with cushions or buffers of india-rubber aud other compressible materials calculated to soften the blow of the shot; but all of these contrivauces were abandoned for a solid teak and English oak backing, averagiug from 9in. to 10in. in thickuess. It was fouud, that the face of the backing to which the plates were attached should be sufficiently stroug and unyieldiug not only to maintaiu the plates in position, but also to prevent them from uudergoing any violent jar from the collisiou of the shot. Wheu such supports were not employed, every shot broke the bolts at the nuts, aud also injured the armour plates as well as the iuuer skin representing the sides of the ship to which they were attached. In ships of war it has been fouud uecessary to increase the thickness of the skin of the ship to which the armour plates are attached from ⅝ to 1in. thick, and, in some cases, it was found essential to have an additional lining of plate from 1¼ to 1½in., united to plates ou edge intervening betweeu the joints of the wood backiug so as to form a stroug bed or compressible cushiou to softeu the blow from the shot as it impiuges ou the face of the armour plate.

The object of the present experiments may be regarded as supplemental to those already recorded, being chiefly iustituted, as I have already stated, to determine the numerical advantage of the oak backing, and to ascertain the strength of double armour plates as compared with the single armour plates. The results of these experiments—which were carefully made—are recorded in the following tables. The formulæ expressing the laws of resistance, &c., as on former occasions, have been deduced from the experiments by my friend Mr. Tate.

First Series of Experiments on Punching.

The Plates restiug on a Steel Die Block.

Experiment 1.

Two ¼iu. Plates riveted together.
Puuch Flat-ended, 1in. diameter. Area, .7854sq. in. Diameter of hole in Die, 2iu. Area, 3.1416 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	10,832	4·835	·05	
2	14,546	6·493	·06	
3	19,150	8·549	·07	
4	20,942	9·349	·08	
5	22,636	10·105	·08	
6	24,316	10·855	·09	
7	25,952	11·584	·1	
8	27,744	12·385	·12	
9	29,424	13·135	·15	
10	31,329	14·030	...	Punched.

Experiment II.

Two ¼in. Plates riveted together.
Punch Point-ended, 1iu. diameter. Area, .7854 sq. in. Diameter of Hole iu Die, 2in. Area, 3·1416 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	22,636	10·105	·4	
2	24,316	10·755	...	Punched.

Experiment III.

Two ½in Plates riveted together.
Punch Flat-ended, 1in. diameter. Area, .7854 sq. in. Diameter of Hole in Die, 2in. Area, 3·1416 sq. in.

No. of Experiment.	Pressure on Puneh per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	22,636	10·103	·02	
2	26,014	11·613	·03	
3	29,454	13·146	·034	
4	31,246	13·949	·04	
5	37,414	16·664	·043	
6	39,998	17·819	·05	
7	51,612	23·040	·06	
8	58,668	26·189	·07	
9	65,804	29·311	·09	
10	69,388	30·966	·1	
11	72,764	32·483	·1	
12	79,948	35,692	·13	
13	84,300	37·633	·15	
14	88,020	39·233	·17	
15	91,604	40·803	·18	
16	94,292	42·064	·2	
17	97,976	43·694	·22	
18	101,470	45·294	·35	
19	103.252	45·988	·38	
20	105,044	46·891	·4	
21	107,836	48·137	·5	
22	109,628	48·937	...	Punched.

Experiment IV.

Two ½in. Plated riveted together.
Punch Point-ended 1in. diameter. Area .7854 sq. in. Diameter of Hole in Die 2in. Area 3·1416 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	37,439	16·679	·15	
2	44,394	19·818	·2	
3	51,612	23·049	·23	
4	58,668	26·188	·28	
5	65,804	29·311	·33	
6	69,388	30·976	·35	
7	73,614	32·860	·4	
8	77,534	34·612	·42	
9	81,006	36·163	·46	
10	84,300	37·633	·5	
11	88,020	39·230	·52	

Experiment IV.—*(contd.)*

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs:	tons.		
12	91,604	40·803	·55	
13	94,292	42·094	·6	
14	98,770	45·096	·62	
15	103,354	45·690	·66	
16	105,838	47·293	·7	
17	109,522	48·305	·78	
18	111,314	49·660	·85	
19	112,210	49·979	...	Punched.

Experiment V.

Thickness of Plate, ¼in.
Punch Flat-ended, 1in. diameter. Area, .7854 sq. in. Diameter of Hole in Die, 2in. Area, 3.1416 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	10,832	4·835	·09	
2	12,624	5·640	·12	
3	14,546	6·493	...	Punched.

Experiment VI.

Thickness of Plate, ¼in.
Punch Point-ended, 1in. diameter. Area, .7854 sq. in. Diameter of Hole in Die, 2in. Area, 3,1416 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	10,832	4·835	...	Punched.

Experiment VII.

Thickness of Plate, ¼in.
Punch Flat-ended 1in. diameter. Area .7854 sq. in. Diameter of Hole in Die, 2in. Area 3.1416 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	10,832	4·835	·02	
2	14,416	6·435	·03	
3	18,356	8·194	·04	
4	23.860	12·651	·045	
5	29,236	13·051	·06	
6	36,608	16·342	·08	
7	45,322	20.233	·13	
8	48,728	21·758	...	Punched.

Experiment VIII.

Thickness of Plate, ¼in.
Punch Point-ended, 1in. diameter. Area .7854 sq. in. Diameter of Hole in Die, 2in. Area 3.1416 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	37,438	16·679	...	Punched.

Experiment IX.

Thickness of Plate, ⅜in. Punch Flat-ended, 1in. diameter. Area. ·7854 sq. in. Diameter of Hole in Die, 2in. Area, 3·1416 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches	Remarks.
	lbs.	tons.		
1	37,438	16·679	·03	
2	44,814	20·005	·04	
3	52,366	23·337	·05	
4	59,108	26·384	·068	
5	66,573	29·719	·08	
6	73,629	32·873	·09	
7	81,021	36·169	·12	
8	88,189	39·291	·16	
9	88,189	39·291	·17	
10	95,493	42·629	...	Punched.

Experiment X.

Thickness of Plate tested, ⅞in. Punch Point-ended, 1in. diameter. Area, ·7854 sq. in. Diameter of Hole in Die 2in. Area, 3·1416 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	37,438	16·713	·15	
2	45,374	20·225	·2	
3	52,222	23·312	·22	
4	59,400	26·517	·26	
5	65,808	29·377	·34	
6	73,104	32·639	·4	
7	80,272	35·834	·53	
8	83,712	37·364	...	Punched.

Experiment XI.

Thickness of Plate, ¾in. Punch Flat-ended, 1in. diameter. Area, ·7854 sq. in. Diameter of Hole in Die, 2in. Area, 3.1416 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	37,438	16·713	·03	
2	45,374	20·255	·032	
3	52,222	23·312	·05	
4	59,400	26.517	·08	
5	67,038	29·926	·1	
6	73,962	35·023	...	Punched.

Experiment XII.

Thickness of Plate, ¾in. Punch Point-ended, 1in. diameter. Area, ·7854 sq. in. Diameter of Hole in Die, 2in. Area, 3.1416 sq in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	37·438	16·679	·15	
2	41,680	18·606	·18	
3	44,094	19·051	·2	
4	46,486	20·251	·21	
5	48,694	21·737	·24	
6	50,374	22·487	·28	
7	52,222	23·312	·33	
8	53,958	24·087	...	Punched.

SECOND SERIES OF EXPERIMENTS ON PUNCHING.

The Plates Resting on a Solid Oak Backing.

Experiment I.

Thickuess of Plate, ¼in.
Punch Flat-ended, 1in. diameter. Area, ·7854 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	13,070	5·835	·14	
2	14,862	6·635	·17	
3	16,654	7·435	·2	
4	20,238	9·035	·4	
5	22,530	10·058	...	Punched.

Experiment II.

Thickness of Plate, ¼iu.
Punch Point-ended, 1in. diameter. Area, ·7854 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	13,070	5·835	·2	
2	14,862	6·635	·28	
3	16,664	7·445	·46	
4	18,436	8·231	...	Punched.

Experiment III.

Thickness of Plate, ½in.
Punch Flat-ended, 1in. diameter. Area, ·7854 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentatiou in Inches.	Remarks.
	lbs.	tons.		
1	37,438	16·713	·14	
2	41,022	18·313	·2	
3	44,606	19·913	·31	
4	48,190	21·517	·41	
5	49,982	22·213	...	Punched.

Experiment IV.

Thickness of Plate, ½in.
Punch Point-ended, 1in. diameter. Area, ·7854 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	37,438	16·713	...	Plate punched with this weight.

Experiment V.

Thickness of plate, ¾in.
Punch Flat-ended, 1in. diameter. Area, ·7854 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	66,798	29·820	·28	
2	73,966	33·021	·37	
3	83,038	37·070	·61	
4	84,638	37·785	...	Sunk with this weight.

Experiment VI.

Thickness of Plate, ¾in.
Punch Point-ended, 1iu. diameter. Area, ·7854 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	37,438	16·713	·1	
2	48,190	21·517	·28	
3	57,390	25·620	·45	
4	64,270	28·692	·78	
5	66,062	29·492	...	Punched.

Experiment VII.

Thickness of Plate, ⅞in.
Punch Flat-ended, 1in. diameter. Area, ·7854 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons		
1	54,254	24·221	·19	
2	75,262	33·600	·34	
3	86,960	38·822	·49	
4	97,712	43·622	·72	
5	101,296	46·003	...	Punched.

Experiment VIII.

Thickness of Plate, ⅞in.
Punch Point-ended 1in. diameter. Area, ·7854 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	37,438	16·713	·13	
2	55,390	34·725	·25	
3	70,366	31·413	·43	
4	77,142	34·438	·64	
5	80,726	36·038	...	Punched.

Experiment IX.

Two ¼in. Plates riveted together.
Punch Flat-ended, 1in. diameter. Area, ·7854 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	23,822	10·634	·2	
2	30,718	13·713	·33	
3	34,238	15·285	·41	
4	36,158	16·142	...	Puuched.

Experiment X.

Two ¼in. Plates riveted together.
Punch Point-ended, 1in. diameter. Area, .7854 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	13,070	5·835	·17	
2	20,238	9·035	·48	
3	23,822	10·634	·5	
4	27,118	12·106	...	Punched.

Experiment XI.

Two ½in. Plates riveted together.
Punch Flat-ended, 1in. diameter. Area, ·7854 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	54,254	24·221	·15	
2	68,350	30·513	·23	
3	83,342	37·207	·4	
4	94,702	42·280	·68	
5	101,870	45·078	·9	
6	105,454	47·078	...	Punched.

Experiment XII.

Two ½in. Plates riveted together.
Punch Point-ended, 1in. diameter. Area, ·7854 sq. in.

No. of Experiment.	Pressure on Punch per Unit of Diameter.		Indentation in Inches.	Remarks.
	lbs.	tons.		
1	37,438	16·713	·34	
2	51,486	22·989	·51	
3	80,078	35·750	·94	
4	98,478	43·963	1·52	
5	99,272	44·317	1·70	
6	101,062	45·117	...	Punched.

TABLE I.

Reduction of Experiments with the Flat-ended Punch.
Single Plates—Plates resting on a Steel Die Block.

Thickness of plate.	Pressure on Punch per Unit of Diameter.		Pressure P on Punch per Unit of Diameter, and Thickness in Tons.	Corresponding Indentation in Inches.
in.	lbs.	tons.		
¼	14,516	6·493	25·972	·12
½	48,728	21·753	43·506	·13
¾	73,962	35·023	46·697	·1
⅞	95,493	42·629	48·720	·17

Here the mean value of P_1 for the three thicker plates is 46.308 tons. Now substituting this value of P_1 in the equality, we find the value of the constant

$$P = C\ rt,$$

C=46.308 tons, and, therefore, $P = 93\ rt$ nearly, where P is expressed in tons, and $P_1 = 210,000\ rt$ nearly. Moreover, putting U for the work expended in perforating the plate,

$$U = \frac{1}{2} P^1 \div \frac{t}{12} = + 210,000\ rt + \frac{t}{12} = 8750\ rt^2,$$

where it will be observed that the constant in this expression for the work of perforation is about one-sixth less than that given in eq. (3) of the first paper.

TABLE II.

Reduction of Experiments with the Flat-ended Punch.
Doublo Plates—Plates resting on a Steel Die Block.

Thickness Plate.	Pressure on Punch per Unit of Diameter.		Pressure P_1 on Punch per Unit of Diameter and Thickness in Tons.	Corresponding Indentation in Inches.
	lbs.	tons.		
2¼in plates	31,328	14·030	28·060	·15
2½in. plates	109,628	48·937	48·937	·5

TABLE III.

Reduction of Experiments with the Point-ended Punch.
Single Plates—Plates resting on a Steel Die Block.

Thickness of Plate.	Pressure on Punch per Unit of Diameter.		Pressure P_1 on Punch per Unit of Diameter and Thickness in Tons.	Corresponding Indentation in Inches.
in.	lbs.	tons.		
¼	10,832	4·835	19·340	...
½	37,468	16·676	33·358	...
¾	53,958	24·087	32·116	·33
⅞	83,712	37·364	42·702	·53

Here the mean value of P_1, for the three thicker plates, is 86,065 tons.

TABLE IV.

Reduction of Experiments with the Point-ended Punch.
Double Plates—Plates resting on a Steel Die Block.

Thickness of Plate.	Pressure on Punch per Unit of Diameter.		Pressure P_1 on Punch per Unit of Diameter and Thickness in Tons.	Corresponding Indentation in Inches.
	lbs.	tons.		
2¼in. plates	24,316	10·855	21·710	·4
2½in. ,,	112,210	49·979	49·979	·85

TABLE V.

Reduction of Experiments with the Flat-ended Punch.
Single Plates—Plates resting on a Solid Oak Backing.

Thickness of Plate.	Pressure on Punch per Unit of Diameter.		Pressure P_1 on Punch per Unit of Diameter and Thickness in Tons.	Corresponding Indentation in Inches.
in.	lbs.	tons.		
¼	22,530	10·058	40·232	·4
½	49,982	22·318	44·636	·41
¾	84,638	37·785	50·380	·61
⅞	101,296	46·004	52·776	·72
Mean			46·956	

TABLE VI.

Reduction of Experiments with the Flat-ended Punch.
Double Plates—Plates resting on a Solid Oak Backing.

Thickness of Plate.	Pressure on Punch per Unit of Diameter.		Pressure P_1 on Punch per Unit of Diameter, and Thickness in Tons.	Corresponding Indentation in Inches.
	lbs.	tons.		
2¼in. plates	46,158	16·142	32·284	·41
2½in. ,,	105,454	47·078	47·078	·9
Mean			39·681	

TABLE VII.

Reduction of Experiments with the point-ended Punch.
Single Plates—Plates resting on a Solid Oak Backing.

Thickness of Plate.	Pressure on Punch per Unit of Diameter.		Pressure P_1 on Punch per Unit of Diameter, and Thickness in Tons.	Corresponding Indentation in Inches.
in.	lbs.	tons.		
¼	18·436	8·230	32·920	·46
½	37,438	16·713	33·426	
¾	66·062	29·492	39·322	·78
⅞	80·726	36·038	41·186	·64
Mean			36·713	

TABLE VIII.

Reduction of Experiments with the Point-ended Punch.
Double Plates—Plates resting on a solid Oak backing.

Thickness of Plate.	Pressure on Punch per Unit of Diameter.		Pressure P_1 on Punch per Unit of Diameter, and Thickness in Tons.	Corresponding Indentation in Inches.
	lbs.	tons.		
2¼in. plates	27,118	12·106	24·212	0·5
2½in. „	101,062	45·117	45·117	1·70
Mean			34·664	

The comparative value of double and single Plates is shown in the following Summary of Results:

SUMMARY OF RESULTS OF TABLES I. AND II.

Thickness of Plate.	Resistance, P_1, in Tons.	
	Single Plates.	Double Plates.
½in. Plates	25·972	28·060
Thick „	46·308	48·937

These results show that the statical resistance to punching, with the flat-ended punch, does not vary much, whether the plates be solid or in two thicknesses; but as the indentations, at the point of rupture, in the double plates are very much greater than they are in the single one, the work expended* in rupturing the double plates is considerably greater than the work in rupturing the single ones.

SUMMARY OF RESULTS OF TABLES III. AND IV.

Thickness of Plates.	Resistance, P_1, in Tons.	
	Single Plates.	Double Plates.
½in. Plates................	19·340	21·710
Thick „	49·979	49.979

These results show that, with the point-ended punch, the ultimate resistance of the double plates is somewhat greater than that of the single plates, and that the work in rupturing the double plates is considerably greater than the work in rupturing the single ones. Similar results are obtained by comparing the results of Tables VII. and VIII.; but comparing the results of Tables V. and VI., it will be found that the advantage is somewhat in favour of the single plates.

Comparing the results of Table I. with those of Table III., it will be seen that the ultimate resistance of plates to the flat-ended punch is somewhat greater than their resistance to the point-ended punch, but that the work expended in perforating the plates by the point-ended punch is considerably greater than that which is expended in perforating the plates by the flat-ended one. Similar observations apply to the plates with the oak backing. Hence we conclude, generally, that the ultimate resistance of plates to punching is nearly the same, whatever the form of the punch may be, yet the work expended in punching with the round-ended, or with the point-ended punch is considerably greater than it is with the flat-ended one. Hence it follows that the flat-ended bolt is the most destructive form of a projectile.

The following Summary of Results shows the advantage gained by the oak backing:

SUMMARY OF RESULTS OF TABLES I. AND V.
Single Plates—Flat-ended Punch.

Thickness of Plates.	Indentation in Inches.		Ratio.
	Plates on Die Block.	Plates on Oak Backing.	
½in.	·13	·41	1 to 3·1
¾in.	·15	·61	1 „ 4·0
⅞in.	·17	·72	1 „ 4·2

Here it will be observed, that whilst the ultimate punching pressures are nearly equal, the indentations of the plates, with the oak backing, are very considerably greater than the corresponding indentations of the plates without the backing. Hence it follows that the dynamic resistance—or work expended in rupturing—of a plate with oak backing is about from three to four times, in this case, that of a plate without backing. The same law may be observed when the point-ended punch is used, as shown in the following summary of results.

SUMMARY OF RESULTS OF TABLES III. AND VII.
Single Plates—Point-ended Punch.

Thickness of Plates.	Indentation in Inches.		Ratio.
	Plates on Die Block.	Plates on Oak Backing.	
¾in.	·33	·78	1 to 2·4
⅞in.	·53	·64	1 „ 1·2

Here the dynamic resistance of the plates with the oak backing is about from 1¼ to 2½ times that of the plates without the backing.

SUMMARY OF RESULTS OF TABLES II. AND VI.
Double plates—Flat-ended Punch.

Thickness of Plates.	Indentation in Inches.		Ratio.
	Plates on Die Block.	Plates on Oak Backing.	
Two ¼in.	·15	·41	1 to 2·7
Two ½in.	·5	·9	1 „ 1·8

Here the dynamic resistance of the double plates with the oak backing is, on an average, 2½ times that of of the plates without the backing.

SUMMARY OF RESULTS OF TABLES IV. AND VIII.
Double Plates—Point ended Punch.

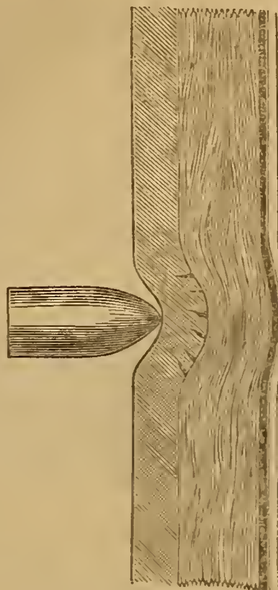
Thickness of Plates.	Indentation in Inches.		Ratio.
	Plates on Die Block.	Plates on Oak Backing.	
Two ¼in.	·4	·5	1 to 1·25
Two ½in.	·85	1·7	1 „ 2·00

Here the dynamic resistance of the double plates, with the oak backing, is on an average, about 1½ times that of the double plates without the backing.

It might be interesting to compare the foregoing results with those derived from the impact of shot where the indentation and work done are nearly the

* In this case, it will be observed, that *the work* is in proportion to the indentations.

same in both cases. The law of resistance of wrought-iron plates to perforation by statical pressure has, to a great extent, been established by the experiments recorded in the reports of the Iron Plate Committee. They were all of them, however, conducted on single plates, and without backing, whereas those in the present paper are made upon both single and double plates, and the perforations effected against a solid steel disc in the first instance, and a cushion of hard oak in the second. From this it will be noticed that the indentations are much greater against the backing which yields to the pressure in form analogous to that produced by the impact of shot. It is quite evident that a perfectly rigid unyielding backing would be a great support to armour plates, as shown in the late experiments on the Fort Target, where three thicknesses of plates were employed, with intermediate spaces filled with iron cement, and forming a thickness of more than 2ft. This construction is, however, not applicable to ships of war and hence the usual teak or oak backing must be resorted to, in order to prevent the breaking of the fastenings.



In the perforation of plates against wood backing the deflection of the plate, whether produced by statical pressure or by impact, is, as near as possible, the same, and may be described as follows:

Supposing an armour plate, attached to the side of a ship, with a backing of hard teak, as shown in the annexed figure. In this position, when struck by a spherical shot, a large area of the plates is deflected forwards into the backing, as shown at A, as may be seen in the every-day experiments at Shoeburyness.

In the experiments recorded in this paper the results as to the deflection of the plate were nearly the same as those produced by shot, and hence the increased depth of deflection under circumstances where the yielding medium of support is wood.

ON THE COMPOUND MARINE STEAM ENGINE.

By Arthur Rigg, jun.

Compound engines of various kinds have been made ever since Mr. Hornblower took out his patent in 1781, but they differ less in their general principles than in the number and arrangement of the cylinders and other mechanical details. They were originally used for pumping at the Cornish mines, but experience proving that they possessed no real advantage over single engines, they have fallen into disfavour, and gradually into disuse. Indeed, when it is considered that the power of such pumping engines is not expended in raising water in the first instance, but in lifting ponderous rods, whose descending weight raises the water, it is obvious that a sudden and very extreme pressure at the beginning, which gradually reduces by the expansion of steam, is an advantage in the single engine and not a demerit. For this extreme pressure takes place at the proper moment for overcoming the inertia of the rods, and the space through which they must be raised ought to be completed by momentum.

When the expanding steam has reached the practical limit of its power, very high degrees of expansion are not advantageous, for more is lost by weakening the engine, extra friction, &c., than is gained by economy of coal, and it seems to be the conclusion of much practical experience that an expansion to about eight times the original volume with steam of the average pressures, gives the best practical efficiency with the Cornish pumping engines.

When engines are required for marine purposes this varying pressure upon the piston becomes an insuperable obstacle to high expansion in one cylinder, for an uniform power is of the utmost value, not only to improve the propelling, but also to avoid the disastrous consequences of frequent irregular strains upon the machinery.

In order, therefore, to secure the economy resulting from high degrees of expansion along with an uniform strain upon the machinery and a regular driving power, compound engines are the best for marine purposes, and are rapidly coming into general favour. Many old engines are being compounded, and few new ones are constructed on any other principle.

The usual type of compound engine is that of the engines of the steamship *Kelpie*. These engines are made by Messrs. Richardson and Sons, of Hartlepool, from the designs of Mr. G. W. Jaffrey. The high-pressure cylinder is 25in. diameter and the low-pressure cylinder 43in., both having the same stroke, 36in., and their cranks are set at 90 deg. with each other. The smaller cylinder is provided with an expansion valve, by the use of which the best practical degree of expansion can be ascertained. Surrounding this cylinder is a large open space, into which the steam passes on its way to the second cylinder, and is permitted to accumulate until the valve of the low-pressure cylinder opens to admit it therein. The capacious character of this receiver exercises a most beneficial influence in preventing back pressure, as shown by indicator diagram.

In the high-pressure cylinder steam is cut off by the expansion valve at points below 21¼in., which is full gear, but in the low-pressure cylinder the expansion begins invariably at three-quarters of the stroke, the total expansion in both being as 1 to 6·77 times the original volume. Each piston has two piston rods, giving great stiffness, and a most convenient crosshead.

In order to start this class of engine it is necessary to admit steam direct from the boiler into the larger cylinder by a pipe; and without this arrangement it would not be possible to manage such engines, and even with it there is at times a difficulty in starting some of them.

Another type of compound engine results originally from the conversion of old engines merely by the addition of high pressure cylinders above the existing cylinders, prolonging the piston and valve rods, re-arranging the steam passages, and using the original gear. By this system two separate independent compound engines are made, each using the same condenser. One of the original air-pumps is used still for the same purpose, and the other becomes a circulating pump for the surface condenser.

Type 3 is the same as Type 2, except that it has only one high-pressure cylinder above one low-pressure cylinder, and both pistons are on the same piston rod, and act upon one crank in the manner represented by the engraving.

For all marine engines of moderate size this would be the cheapest, most compact, and best arrangement, but from the difficulty of starting and reversing consequent upon the dead centres of the single crank. Many plans have been tried for overcoming this difficulty, even to the cumbrous one of a large fly-wheel, which is of no use when the crank stands upon its centre. The fly-wheel, too, is a considerable increase to the load a vessel has to bear; first, its actual weight reduces the cargo that might be carried; and, secondly, it offers resistance to the easy motion of the ship. Such a fly-wheel resembles nothing so closely as an enormous gyroscope mounted upon an admirable universal joint. It is well known with what energy a little gyroscope resists attempts to change its plane of rotation; so likewise, but on a far vaster scale, the operation of the fly-wheel in the ship resists the freedom of pitching, and throws a very heavy strain, not only upon the bearings of the engine shaft and ship framing consume power, and therefore reduce progress. Now since power is derived from the engine, it may be expressed in terms of coal consumed. The fly-wheel, then, is an appliance not only imperfect, but actually injurious to the engine, the ship, and the speed.

A method of turning the crank over its dead centre should be light and simple, worked by the usual handles, and be a store of power that will enable the engine to start from whatever position of the crank it may have come to rest; in short, it ought to give to the single crank compound engine, Type 3, the same uniformity of driving power as may be now attained by compound engines of Types 1 or 2, with the cranks set at right angles to each other. An apparatus of this kind has been contrived and successfully used by Mr. Macgeorge, of this city, and the author of the present paper, and the principles of its action will be described later on.

The first inquiry of interest is to ascertain the best grade of expansion to use with steam of the usual pressures, avoiding both extremes, namely, the waste of steam containing useful energy, or the carrying expansion, so far as to reduce the power of the engines below that which their size and cost ought to furnish. These points were illustrated profusely by indicator diagrams.

The following table gives the general results:—

Fig. 1.—Engines of S.S. "Kelpie."—Performance with different grades of expansion

Steam cut off at.	Ratio of expansion.	Initial pressure.	Revolutions per minute.	Steam Gauge.	Vacuum	Mean pressure. High pressure.	Mean pressure. Low pressure.	H.P. of high pressure cylinder.	H.P. of low pressure cylinder.	Total H.P.
		lb.		lb.	in.	lb.	lb.			
Full gear, 22¼in.	1 to 6·77	47	77	55	26	27·7	7·6	190·3	154·5	344·8
20in.	1 to 7	50	72	57	26	28·8	9·4	185	178·7	363·7
17in.	1 to 8·4	50	72	55	26	27·7	9·1	178	173	351
12in.	1 to 12	47	64	50	26·5	23·3	6·27	133	105·8	238·8
8in.	Omitted on account of the engine priming.									
4in.	1 to 36	53	52	58	25·5	17·1	4·3	79	59	138

When cutting off steam at 22in. this engine consumes 6 tons 16 cwt. of coal daily, which, taking the indicated H.P. = 344 at 68 revolutions per minute, will realise 1-H.P. per hour by the consumption of 1·84 lb. which is the usual working expenditure.

In order that the driving power be uniform it is necessary that the cranks shall stand at right angles with each other; but there is an objection to this arrangement in compound engines of this kind, because the low-pressure cylinder makes its largest demand upon the steam while none is entering the reservoir from the high-pressure cylinder, and the exhaust from the high-pressure cylinder enters into a partly closed reservoir. The only possible arrangement for meeting this difficulty is that referred to, namely, the capacious character of the reservoir between the two cylinders and as expansion therein takes place without doing any work, adiution will be the chief source of loss.

In the majority of instances, however, the influence of the imperfect accommodation for the steam may be traced on the indicator diagrams. To remove this difficulty is to place the cranks opposite or nearly opposite to each other.

The most suitable arrangement for accomplishing both conditions of easy passage of steam and regular driving is a double set of engines; but it is very complicated, and a single framing, crank and two cylinders, with the turning gear to obviate the dead centres, forms the cheapest engine, and fulfils all conditions iu the most complete and efficient mauner.

Fig 1.

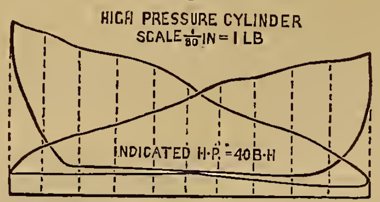
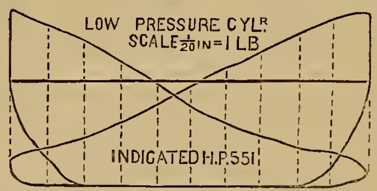
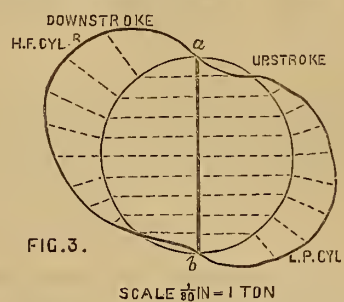


Fig. 2.

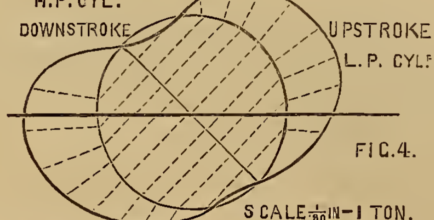


Economy of Compound Engines.—To illustrate this question, no better examples can be giveu than the same engiue and ship before and after couversion, and now altered into compound eugines of the class described as Type 2. The original engines, in one case, whose cylinders were 38iu. diameter and 30in. stroke, boiler pressure 23lh., and revolutious per minute, sixty, indicated 360-horse power; coal, thirteen and a-half tons per day, equal to 3·5 lb. per hour per horse-power. These engiues are now altered into a pair of compounds by the addition of cylinders 21iu. diameter, the original 38in. cyliuders beiug used for low pressure. Of course surface condensers are added, with the usual arrangements. The boiler pressure is unfortunately limited to 45 lb. per square inch, owing to the engines not haviug been originally intended for high pressure; but uo douht the existing advantages of compounding would have been greater if the pressure could be raised. The results of conversiou are—Horse-power of high-pressure cylinders equal to 231; horse-power of low-pressure cyliuders equal to 223; total 454-horse-power; and the amouut ohtained from each pair of cylinders may be considered alike for all practical purposes; and 1-horse-power is produced by a cousumption of 2·22 lb. of coal. The contrast in economy and power between the old arraugement of an ordinary double engine and the new system of a double compouud engine is sufficiently obvious. In the one case 360-horse power is produced hy burning thirteen aud a-half tons of coal daily; in the other case 455-horse power is produced by burniug 10·8 tons of coal daily.

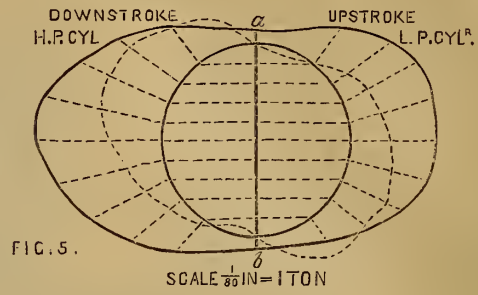
Pressure acting Tangentially to the Crank.—Allusion has heen frequently made to the advautage of an uniform driving power, and it will be well to place this question in such a light that the different arrangements of compound engines shall he clearly seen in relation to their twisting power upon the screw shaft. In order to kuow the effective pressures acting at right angles to the



radius upon the crank pin, a simple calculation gives the diagrams 3, aud 4 These represent the actual tangential pressures upon the crauk pin in tons set



off upon a circular base line to scale of one-eightieth of an inch to the ton. A more extensive instance of the irregular drivIng power of this class of compound engine is given in Diagram, Fig. 5. Iu this case the high-pressure cylinder is 46in. diameter; low-pressure cyliuder, 80in. diameter; stroke, alike



in both, 39in. diameter; angle of cranks to each other, 135 deg.; horse-power of high-pressure cylinder equal to 403·5; horse-power of low-pressure cylinder equal to 551; total, 954·5 horse power. Fig. 3 represents the tangential pressures upou the high-pressure crauk, and Fig. 4 those upon the low-pressure crank, whilst Fig. 5 shows the combined action of both. At *a* aud *b* (the dead centres of the high-pressure cylinder) the tangential pressure upon the crank pin is five tons in the combined diagram, while the maximum pressure is fifty tons—a variation of 1 to 10. Contrasting iu the most striking manuer with these results are the diagrams now calculated from the converted engine, Type 2.

Conclusions from the foregoing Calculations on the Tangential Pressure on the crank circle.

Description of engine.	Minimum tangential pressure.	Maximum tangential pressure.	Variation.
Engine with cylinders side by side and	5 tons	22 tons	1 to 4·4
Steam for one cylinder enters the other	5 tons	50 tons	1 to 10
Duplicated engines with one cylinder above the other..................	9·31 tous.	13·5 tous.	1 to 1·46

Iu couverting old engiues, therefore, it may he coucluded that the better plau is to leave the origiual cylinders in use for low-pressure and to add high-pressure cylinders above them, and not to displace both cylinders and work one engine by the exhaust steam from the other. It is easy to apply the same considerations to new engines, and the plau of one cylinder above the other described as Type 3 is better than Type 1 from its giving a better distribution of the steam in the first instance, and from its being much cheaper to construct and lighter iu weight. Added to these advantages, there is the important commercial consideration of occupying less valuable space in the ship thau any other kind of engine. The second cylinder fills a space that under uo circumstances could be utilised for the stowage of cargo.

The ouly difficulties in the way of using such engines are the unbalanced conditiou of their moving dead weights, aud the difficulty of giving an uuiform twisting power upon the screw shaft. Incidentally, the difficulty of starting and reversiug will be removed, if the driving power is alike duriug every part of the crauk's revolution.

The balancing of the moving deadweights may be accomplished by a balance weight attached to the crank, by the cut-off of steam, or a separate piston or in other ways. The difficulty of starting such engines and producing au equable driving power seems at first sight more serious, and many devices have been tried as remedies. The turning gear illustrated in the figure is the most recent of these, and has heen contrived to meet the difficulty. Its original form was that of a cam upou the engine shaft, with a large roller working upon it, and held agaiust it hy steam pressure. This plan has been applied to a pair of compouud screw engines of 100 nominal horse-power of Type 1, having the cranks opposite to each other; aud when in operation it enables the engiues to start, reverse, or turn slowly round iu a very perfect mauner. It is not, however, so well adapted to marine engines as to those ruuuiug in one direction, in consequeuce of the extra handles necessary to reverse; and the plan illustrated has been coutrived to adapt the same principles which work so successfully with the cam arrangement to the compound marine engine, Type 3, namely, one cylinder above the other. The cyliuders of the engine are taken 25in. and 48in. diameter, and 30in stroke, and the corresponding diameter aud stroke of the turning gear cylinder would be 18iu and 12in. respectively.

Fig. 8 represents the turning gear applied to the engine above described, while the diagrams 6 and 7 show differeut portions of the apparatus.

The supplementary crank B is attached to the free eud of the screw shaft, and joined by a couuectiug rod C to the piston rod of the oscillating cylinder F, and to the link D E, which moves freely upou the centre D. There is also a reversing valve (not shown) in connection with the steam pipe G, and the handle H, so that pressure can be admitted to either side of the piston in the oscillating cylinder F.

Action of the Apparatus.—In order to turn the main crank off its dead centre in the direction of the arrow, and to secure uniformity of driving power

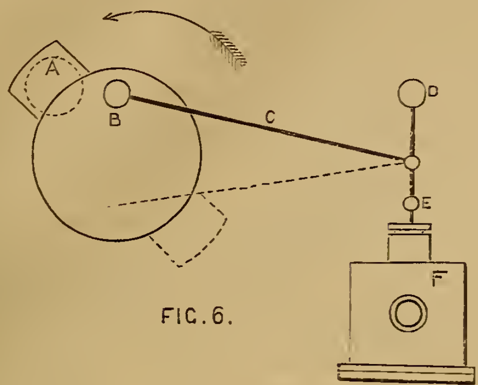


FIG. 6.

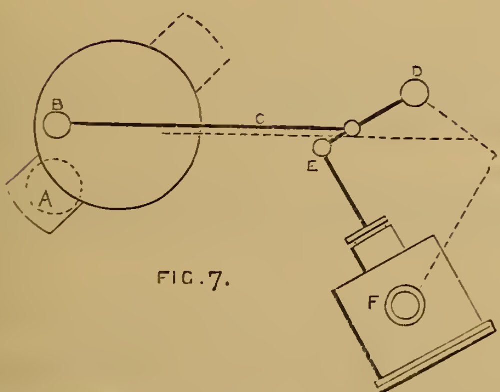


FIG. 7.

steam is admitted continuously to the upper side of the cylinder F, while the lower side is in connection with the condenser. As the centres D and those of the cylinder F are fixed, it is evident that the pressure will tend to turn the apparatus into the position shown by Diagram 6, whereby the crank B is forced in the direction of the arrow, thereby turning the main shaft. When the main cylinders can exercise any power, the shaft is turned partly by them and also by the cylinder F., until the position shown in Fig. 6 is reached, when the whole action of the cylinder F is reversed, and it absorbs power while the main crank can best spare it. At position 7 the piston in F has been drawn to the top of its stroke against the steam pressure, and thence begins to restore its power to the main shaft by assisting its motion, and eventually turning it over the lower dead centre. By this system a transfer of power takes place, and the driving is rendered uniform. A similar action occurs during the up-stroke, and the addition of this apparatus would render the action of a compound engine Type 3, having only two cylinders, about as uniform as Type 2, having four cylinders, and the complication of two engines.

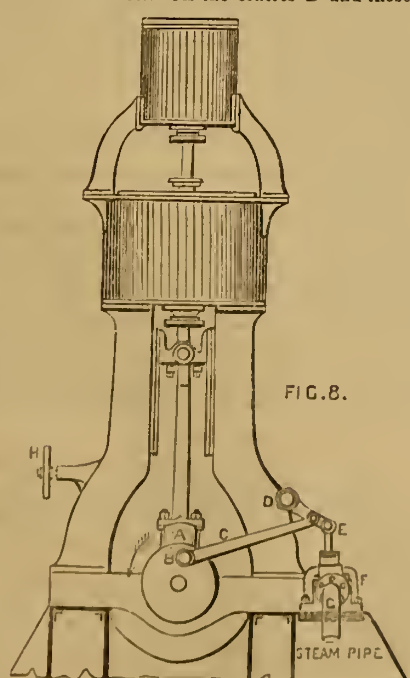


FIG. 8.

The reversing of the turning gear takes place with that of the main engine for the handle H, which moves the link, at the same time works the reversing valve, and changes the direction of steam pressure in the cylinder F.

INSTITUTION OF CIVIL ENGINEERS.

PREMIUMS, SESSION 1869-70.

The Council of The Institution of Civil Engineers have awarded the following premiums :—

1. A Telford medal, and a Telford premium, in books, to Edward Dobson, Assoc. Inst. C.E., for his paper on "The Public Works of the Province of Canterbury, New Zealand."

*2. A Watt medal, and a Telford premium, in books, to R. Price Williams, M. Inst. C.E., for his paper on "The Maintenance and Renewal of Railway Rolling Stock."

*3. A Watt medal, and a Telford premium, in books, to John Thornhill Harrison, M. Inst. C.E., for his paper on "The Statistics of Railway Income and Expenditure, and their bearing on future Railway Policy and Management."

4. A Telford medal, and a Telford premium, in books, to Thomas Sopwith, Junior, M. Inst. C.E., for his paper on "The Dressing of Lead Ores."

5. A Telford medal, and a Telford premium, in books, to James Nicholas Douglass, M. Inst. C.E., for his paper on "The Wolf Rock Lighthouse."

6. A Watt medal, and a Telford premium, in books to George Berkley, M. Inst. C.E., for his "Observations on the Strength of Iron and Steel, and on the Design of parts of Structures which consist of those Materials."

7. A Watt medal, and a Telford premium, in books (to consist of the second series of the Minutes of Proceedings, vols. xxi. to xxx. inclusive), to Robert Briggs, of Philadelphia, U.S., for his paper "On the Conditions and the Limits which govern the proportions of Rotary Fans."

8. A Watt medal, and a Telford premium, in books, to Edward Alfred Cowper, M. Inst. C.E., for his paper on "Recent Improvements in Regenerative Hot Blast Stoves for Blast Furnaces."

9. A Telford premium, in books, to John Grantham, M. Inst. C.E., for his paper "On Ocean Steam Navigation, with a view to its further development."

10. A Telford premium, in books, to Daniel Makinson Fox, M. Inst. C.E., for his "Description of the Line and Works of the San Paulo Railway, in the Empire of Brazil."

11. The Manby premium, in books, to Emerson Bainbridge, Stud. Inst. C.E., for his paper on "Coal Mining in Deep Workings."

The Council have likewise awarded the following Prizes to Students of the Institution :—

1. A Miller prize to Robert William Peregrine Birch, Stud. Inst. C.E., for his paper on "The Disposal of Sewage."

2. A Miller prize to Henry Thomas Munday, Stud. Inst. C.E., for his paper on "The Present and the Future of Civil Engineering."

3. A Miller prize to William Walton Williams, Junior, Stud. Inst. C.E., for his paper on "Roads and Steam Rollers."

4. A Miller prize to Sidney Preston, Stud. Inst. C.E., for his paper on "The Manufacture and the use of Portland Cement."

5. A Miller prize to Edward Bazalgette, Stud. Inst. C.E., for his paper "On Underpinning and making good the Foundations of the Irongate Steam Wharf, St. Katherine's, London."

6. A Miller prize to Josiah Harding, Stud. Inst. C.E., for his paper on "The Widening of the Liverpool and Manchester Railway between Liverpool and Huyton, and on the Construction of a Branch Line to St. Helen's."

7. A Miller prize to the Hon. Philip James Stanhope, Stud. Inst. C.E., for his paper on "The Metropolitan District Railway."

INDIA PUBLIC WORKS DEPARTMENT EXAMINATION.

We give below the questions propounded at the competitive examination of the candidates for engineering appointments in the Department of Public Works in India, as a guide for those young engineers who may be intending to take part in some future examination.

PRACTICAL ENGINEERING PAPER.

Mr. George Preston White, C.E., Examiner.

Candidates are particularly requested to attend to the following directions—(1) Prefix the number of the question to each answer; (2) write legibly and neatly, and answer the questions as concisely as possible; (3) use free-hand sketches or diagrams, wherever possible, to illustrate the answer, which must be carefully executed, in order to show the candidate's proficiency in this style of drawing; (4) candidates must not, during the examination, refer to any book or MS., nor communicate with each other; (5) candidates are required to produce *bona fide* finished drawing, with certificate of their having been solely executed by the candidate, respecting which there will be a *viva voce* examination; (6) write on both sides of the paper, leaving a margin of about an inch.

1. What are the scales usually adopted for parliamentary and contract plans and sections, contract drawings, and drawing for workmen?

* Have previously received Telford medals.

2. Give us a free-hand sketch of an arch of 30ft. span struck from three centres, and one of 250ft. span with eleven centres, marking clearly the positions of the centres, and the lengths of the radii.
3. What is the locus of centre of curvature generally adopted for the face of a curved retaining wall, and what is the usual proportion between the radius of curvature and height of the wall?
4. What is the usual proportion between the thickness of the wall and the distance between the counterforts?
5. How many ordinary bricks are contained in a cubic yard of brickwork, and how much will a bricklayer with attendance lay in a day?
6. What are the relative spaces which 100 cubic yards of cutting will occupy in embankment in the following materials, viz., sand, gravel, clay, and rock in large pieces?
7. In carrying excavation to embankment, up to what lengths of lead can barrows, carts, or waggons drawn by horses be employed to advantage?
8. How much will a labourer get in the day in the following materials, viz clay, stiff-clay, gravel, and sand respectively?
9. How much can he fill in a day in cubic yards?
10. How much, run to a distance of 20 yards, with barrows?
11. Compute by the prismoidal formula the total quantities of cutting or embankment between the heights 2′, 24′, 30′ 28′, 14′ 6″, 0′, 22′, 27′, 35′, and 12′ 6″, heights being taken at 200ft. apart on an average line of quantities base, 30ft., and slopes 1½ to 1.
12. What would be the results of computing these quantities by the methods of mean areas and mean heights respectively?
13. Supposing that these heights and distances had been taken along the centre line of a proposed railway, and that the ground has an inclination of 1 in 9 on each side of the centre line transversely; calculate the amount of land required for the work, adding a constant quantity of 9ft. on each side for fencing; base and slopes as before.
14. Calculate the total area of slopes.
15. Give a free-hand sketch, elevation, plan, and section of a 6ft. culvert in brick, under an embankment 30ft. in height, base 30ft., slopes 1½ to 1, figuring thereon the principal dimensions.
16. Calculate the total amount of brickwork in same.
17. Draw a free-hand sketch, plan, elevation, and sections of a public road bridge over a railway in 25ft. cutting, base and slopes as above, width between parapets 26ft.; materials, bricks, with face voussoirs and quoins of rock-ashlar, string course coping and impost of tooled ashlar.
18. Write a detailed specification for same.
19. Give a detailed estimate of quantities and cost of same, prefacing your estimate with a list of prices of materials, rates of wages. and other data on which it is based.
20. Draw a free-hand sketch, plan, elevation, and sections of a bridge over a river 120ft. wide, depth of water 6ft., level of roadway 25ft., above surface of water; foundations, stiff clay at 12ft. below surface of water; materials, tooled ashlar.
21. Write a specification for same.
22. Give an estimate based on prices of materials and rates of wages as before.
23. It is required to carry a stream across a railway in 20ft. cutting, which stream must not be diverted; how would you deal with it? and give a sketch of the work required, assuming that a 4ft. culvert would be sufficient to carry the stream under embankment.
24. What is the usual amount of coning given to the wheels of a locomotive.
25. How much cant should be given to the rails?
26. Assuming the super-elevation of the outer rail to be found to be 3in. by calculation on the English narrow gauge, 4′ 8½″, how much should it be on the broad gauge and Indian gauges respectively, the conditions as to speed and curvature being identical?
27. What do you consider the best gauge for a light railway with ruling gradients of 1 in 60, average rate of speed 15 miles per hour, maximum curves seven chains radius?
28. What kind of permanent way do you consider best suited for such a railway?
29. Give a short description of the best class of locomotive engines and rolling stock for same.
30. Assuming the greatest load on one driving wheel to be 3¼ tons, what weight of section of rail should be adopted?
31. Explain the following terms:—Blind siding, three throw switches, block system, facing points, train staff, diamond crossing, and falling points,
32. Give cross sections of a turnpike road in side cutting, on level ground, through excavation, and on embankment.
33. Assuming the draught of 1 ton, on a well-made pavement, to be 33 lb., how much would it be on broken stone surface laid on concrete bottom, on old flint road, and on gravel road and stone tramway respectively?
34. At what inclination would the resistance become equal to the resultant of gravity in each of the above instances?
35. Name the best descriptions of stone for road metalling, and the best seasons of the year for repairing roads.
36. Draw a cross section of a canal on a 6ft. embankment, to be used by boats drawing 5ft. 6in. of water and 9ft. in beam.
37. Specify what precautions should be taken to render the channel water-tight, and prevent leakage.
48. What loss of water per day should you provide for in a canal of this kind, exclusive of the loss of water from passage of boats, in England and the tropics?
39. If proposed to irrigate a strip of land five miles in length and half a mile in width, lying alongside of this canal, so as to raise three crops in the year, what alteration would you make in your cross section; and what works should you provide to regulate the supply and discharge of the irrigation water, supposing for instance, you were at liberty to take the requisite amount from a large river at one end of your canal?
40. Write a short specification for Portland cement concrete in sea works, specifying the specific gravity of the cement, the tensile strain which the mass should be able to bear after seven days' immersion, the precautions to be taken in selecting the shingle, and the provisions necessary to prevent disintegration before the final process of induration.
41. Name some of the special advantages derived by a civil engineer, from a knowledge of the science of geology, in planning and executing public works, such as railroads, common roads and canals—especially the latter.
42. Define the terms "system" and "formation" as used in geology.
43. Write a short description of the general distribution of the stratified rocks over the British Islands; and deduce the principal localities in which you would expect to find building stones.
44. Name a few of the characteristic fossils of the Silurian, red sandstone, carboniferous, and new red sandstone periods.
45. What geological system in the British Isles is most rich in minerals?
46. In what systems are Llandello flags, Aymestry limestone, gypsum, mountain limestone, Bath stone, millstone grit, respectively found?
47. What is meant by the terms granite, greenstone, basalt, trachite, pitchstone, porphyry, amygdaloid?
48. What is meant by the "dip" and "strike" of strata, and how are they determined?
49. What is meant by the terms "joint" and "cleavage;" and to what peculiar relation between these is the quality of good building slates attributable?
59. What is the difference between gneiss and mica slate?
51. What is the difference between "dykes" and "veins;" and what is a flukan?
52. What is meant by a "fault" or "trouble?"
53. When a miner encounters a fault in a bed of coal what course does he pursue to hit again on the same bed?
54. Name one of the most remarkable faults in the world which occurs in the English coalfields, and give a short description of its character and extent.
55. What are "farewell" beds, and why so termed by miners?
56. Given two specimens of recent fracture of two pieces of cast iron, one presenting a crystalline, white, and radiated appearance, the other a granulated and grey appearance with some metallic lustre; what qualities would you expect in each of these castings, and for what particular purposes should you select one in preference to the other?
57. Specify the daily tests of the quality of cast iron you should require from the metal used in castings as to fracture and deflection under transverse strain. Do you consider a tensile test also desirable; and if so, what strain per square inch should you require to be borne before fracture?
58. In making patterns for castings how much shrinkage should be allowed for the contraction of the metal in cooling?
59. Give free-hand sketches of the following superstructures in wrought iron, applicable to either public road or railway, with detailed sketches of the principal parts, figuring the dimensions. Note.—The maximum load distributed to be two tons per lineal foot in addition to the weight of the structure:—Ordinary plate girder, 25ft. span; lattice girder, 60ft. span; Warren's girder, 80ft. span.
60. Calculate the weights, write a specification, and estimate the probable cost of each in detail.
61. Give a free-hand sketch of a wrought iron roof suitable for a railway terminus, of 100ft. span, figuring thereon the principal dimensions and scantlings.
62. Write a specification for same, and state therein the character of covering to be adopted.
63. Estimate the cost of same.
64. What are the best kind of timber to select in the following positions—entirely immersed in water, in mud, between wind and water, and exposed solely to atmospheric action?
65. What are the chief advantages of the rib in groined vaulting, both constructively and decoratively?
66. What are the essential characteristics of classic architecture, as opposed to gothic—in their proportions and composition—mouldings and other detail?
67. What are the various means adopted to place a spherical dome on a square base, and name the chief buildings in which these several means may have been adopted?
68. Define the word "order"—

(1st). In classic architecture, giving examples of same.
(2nd). In gothic architecture, ditto.

69. How and by what means is the thrust of the gothic vault of a cathedral nave concentrated and counteracted?
70. What is meant by single and double floors, and the object of the latter?
71. The circular apse of a Romanesque church, 20ft. in diameter, is covered by a hemispherical vault, which it becomes necessary to protect from the weather; show how you would arrange the timbers of the roof, supposing the pitch of the roof to be only 45 deg.; and what precautions you would take to break the joints of the slate covering, and prevent the rain from getting in.—N.B.—The roof would pitch against the eastern end of nave wall.
72. Sketch three or four wooden roofs fit for churches, 25ft span.

SURVEYING AND DRAWING

AFTERNOON PAPER.

(*Time allowed*, 4 *hours.*)

[The figures may be left in pencil, provided they are distinct and neat. Constructions of Nos. 1, 2, and 3 must be shown by dotted lines. The absence of the necessary construction lines will render the figure of little worth, however correct the result may appear. The candidate is recommended to execute all the figures in pencil first, and to ink them in afterwards if he has time.]

1. (*a*) Construct an isosceles triangle, on a base of 2in., with vertical angle of 40 deg. (*b*) Describe a circle about this triangle. (*c*) Describe a square about this circle, one side passing through one of the ends of the base of the inscribed triangle. Ascertain by measurement the length of a side of this square, and write it down.

2. Construct a scale of 5¼ft. to an inch, showing 20ft. on the right of zero, and 10ft. divided into feet on the left of it. The scale to have an upper and lower line ⅛in. apart. Print above it in Roman characters—Scale of 5¼ft. to an inch.

3. A regular pentagon of side 1½in. is the base of a prism 4in. long: draw the plan and end elevation of this solid when its long edges are inclined at 30 deg. to the horizon and one side of the base is horizontal.

4. Copy the accompanying elevation of standard of a windlas on one and a-half times the scale of the copy.

5. Copy the accompanying drawings of the front and side elevations of the two ends of a crank rod. To be done on one and a-half times the scale of the copy, and the parts left incomplete in that to be filled up.

(Nos. 4 and 5 may be coloured if time admits, and any elaboration added that is thought desirable.)

SURVEYING.

MORNING PAPER.

(*Time allowed*, 2½ *hours.*)

[The candidate's object being to obtain as many marks as possible, he is recommended not to answer the questions in the order set down, but to take up those first which he finds easiest, and afterwards the more difficult ones. Although great importance is attached to completeness and accuracy in answering the questions, the candidate is cautioned against unnecessary diffuseness. No values will be assigned to any matter which is not strictly relevant to the question put.]

1. A building lot has a frontage of 32ft. and depth of 80ft. What is the area of the lot in land measure, and what are its length and breadth in links?

2. Find the area in land measure of the field A B D E C, the measurements of which with the Gunter's chain are given in the following field book:—

	to E	
	825	
D 300	475	
	350	150 C
B 100	150	
Begin at	A	

3. Find a general formula to express the correction which has to be made in the computed height of objects on account of the curvature of the earth.

Example. A station six miles off appears to be 76ft. higher than the place of observation. What is its real elevation above the latter after the correction is made for curvature?

What are the respective advantages of the Y and the dumpy or Gravatt level? Explain the reasons for those advantages distinctly.

5. Describe Mr. Gravatt's method of examining and correcting the collimation of a level, explaining the nature of the process by sketches. Show, also, why this method provides a practical correction for curvature and refraction in short distances.

6. In trigonometrical surveying it frequently happens that we cannot set up the theodolite in the centre or axis of the station from which we have to measure the angle subtended by two distant stations, but are obliged to set up the instrument at a point near the station. Explain the nature of the correction necessary in the angle observed from this point (or satellite station) in order to obtain the angle that would have been observed from the inaccessible station.

7. Two lines of railway, Ax, By, have to be connected by curves beginning at A and B; state how many curves will be required, and explain how you would determine them and set them out. (The angles xA B and A By are both obtuse, and xA and By are on the same side of the line A B; the curves are to be on that side also.)

8. Explain the principle upon which the sextant is constructed.

9. Explain the nature of traverse tables, and how they facilitate the computation of traverses executed with theodolite and chain.

MORNING PAPER.

Time allowed, 4 *hours.*

FIRST PART.

1. Complete the accompanying field book of levels, and prove the accuracy of the reduced levels by totalling the figures in the usual manner. The stations are ten chains apart.

2. Plot the levels: vertical scale 3⅓ft. to an inch, horizontal scale ten chains to an inch.

3. Lay down the section of a line of railway to connect the N. and S. railways at stations 1 and 12, in view to the embankment and cutting being as small as possible.

Maximum gradient allowed 1 in 330, and the gradient to be altered only at one of the ten intermediate stations.

Gradients to be stated in print.

Numbers of the stations to be entered in section; also the reduced level at each.

Scales are not required.

The plotting may be done in pencil only, the ground line being shown in fine, and the formation level of proposed railroad in dark line, and vertical heights in dotted lines.

(The table of levels has to be given up to the examiner with the rest of your work).

LEVELS TAKEN BETWEEN N. AND S. RAILWAYS.

Remarks.	Back.	Stations	Forward.	Difference. +	Difference. −	Reduced levels.
At (·) height of instrument 5·02		1	3·18			11·08
Height of (·) above datum	7·33	2	4·25			
Of formation level, N. Railway, 8·38	6·71	3	5·19			
Of bench mark on ground, 11·08 ...	5·82	4	3·72			
	4·86	5	5·19			
	5·02	6	5·67			
	4·42	7	6·79			
	5·50	8	8·64			
	6·30	9	7·20			
At (11), forward reading to (12)— ...	7·09	10	3·29			
At bench mark on ground, 3·45......	6·35	11	3·45			
At formation level S. Railway, 2·10		12				

SECOND PART.

Give specimens of your topographical drawing of the conventional signs for woods, plantations, sand, rocks or cliffs, meadows, gardens, houses, churches, roads, bridges, hilly ground, or any of these.

The drawing may be in pencil or pen, and with or without colour, and isolated specimens may be given, or they may be worked up into one composition.

SURVEYING.

AFTERNOON PAPER.

Time allowed, 2½ *hours.*

NOTE.—You are recommended to read over the questions carefully, before beginning to answer them. This will assist you to frame your answers systematically with regard to the time available. Avoid diffuseness, but be careful to frame your replies so distinctly that the reader may be able to learn from them the *exact* nature and extent of the surveying work you have performed. The questions are to be answered separately in respect of each survey on which you have been employed, so far as they are applicable to it. The questions need not be written out by you, but only the number of it attached to each answer. It will add to the value of your replies if you illustrate them by free-hand pen or pencil sketches.

I. Specify the different surveys or surveying operations which you have executed or have been employed upon. (1) While under instruction. 2 In actual practice for professional purposes, as pupil or assistant.

II. Give a detailed account of each of these surveys, with special reference to the following points:—

1. The locality and extent, and for the purpose which it was undertaken.
2. The kind of survey; whether with chain only, or with chain and compass, or with chain and theodolite, or by triangulation, &c.
3. If under instruction, the name of tutor or instructor. If for engineering purposes, the name of the engineer and company or person for whom it was undertaken.
4. Whether the survey was executed with or without the tutor or engineer's immediate supervision.
5. Number of students or persons who formed the surveying party.
6. Observations with instrument, by whom made.
7. Chaining, by whom executed.
8. Instruments, by whom carried from point to point.
9. Place of residence; and journey therefrom to place of survey, how performed.
10. Dates of beginning and ending the survey.

Next describe the number of separate operations carried out in this survey; thus, in the case of a trigonometrical survey, specify—

11. Length of base, and how it was measured, and how the measurements were checked.
12. Area triangulated, and number of stations.
13. Observations, how made; and description and size of instruments employed. State how many times the observations were repeated.
14. Give specimen of field-book used.
15. Sides of triangles, how determined? If calculated, give the formula used.
16. Time occupied in triangulation, *i.e.*, days and hours per day.

As to the filling in of the survey, state—

17. If a plane table was used, and mode of using it, and number of days during which it was used.

With respect to traversing, state—

18. The number of miles traversed, specifying localities.
19. Nature of instruments employed.
20. Strength of party; whether whole party engaged on the survey executed the traversing together, or was subdivided over different lines.
21. Number of days occupied in traversing.
22. Give specimen of field-book

As to contouring, if any was done—

23. State number of days you were employed on it.

If the filling-in was done with a prismatic compass, state—

24. Whether it was used with or without stand.
25. Mode of working with it.
26. Number of days it was used.

If the survey was executed with prismatic compass, without use of theodolite, state—

27. Length of base, and describe mode of measuring it.
28. How the points in the survey were fixed, and how many independent bearings were taken to each point.
29. How the errors in the compass readings were distributed in the plotting.
30. How the survey was filled in.
31. Give specimen of field-book.

As to the plotting, state—

32. The scale on which the plan was executed, and size of the paper.
33. The instruments used in plotting.
34. Whether the plan was coloured.
35. Whether you executed the plan entirely yourself, or whether more than one person was employed on the same plan.
36. Number of days you were engaged upon the plan, and (average) number of working hours per day.

As to levelling, answer Questions, 1, 3, 6, 7, 8, 9, 10; also—

37. State the lines along which levels were taken, and whether they were isolated lines, or connected with other surveys executed by you which you have now described.
38. The strength of the party employed.
39. The distribution of work among them.
40. The nature of the instruments used.
41. The distance at which sights were taken.
42. The number of cross sections taken.
43. Number of days employed on levelling.
44. Instructor, whether present or not.
45. Plotting, on what scale.
49. Number of days occupied in plotting.
47. Whether plotting was executed wholly by yourself.
48. Give specimen of field-book-

As to the levelling executed in connection with such railway survey, answer the Questions 37 to 44, and 48, given above.

State also—

54. The scale on which the survey was plotted.
55. The scale on which the sections were plotted.
56. The mode adopted for laying down the curves.
57. The number of days occupied in plotting the work.
58. Whether the plan was done by yourself.

With regard to any work laid out by you, specify—

59. The work laid out, and the purpose for which it was done.
60. The mode of laying it out.
61. The instruments employed.
62. The persons engaged.

In the case of railway or road work laid out, describe also—

63. The precise method adopted for laying out the curves, taking one as an example.

Add also—

64. The time which the work took to perform.

[The same questions to be answered separately in respect of each survey which the candidate may have been employed upon, so far as they may be applicable, but specimens of the same kind of field-book need not be repeated: it will be sufficient to refer to the previous ones.]

MATHEMATICS.

Rev. Dr. Wrigley.

July 4, 1870; 10 a.m.—1 p.m.

Euclid.

1. The greater side of every triangle is opposite to the greater angle.
2. If two triangles have two angles of the one equal to two angles of the other, each to each, and one side equal to one side, namely, sides which are opposite to equal angles in each; then shall the other sides be equal, each to each, and also the third angle of one equal to the third angle of the other.
3. The complements of the parallelograms which are about the diameter of any parallelogram are equal to one another.
4. In every acute-angled triangle, the square on the side subtending an acute angle is less than the squares on the sides containing that angle, by twice the rectangle contained by either of these sides, and the straight line intercepted between the perpendicular let fall on it from the opposite angle and the acute angle.
5. The opposite angles of any quadrilateral figure inscribed in a circle are together equal to two right angles.
6. From a given circle to cut off a segment containing an angle equal to a given rectilinear angle.
7. To describe a circle about a given equilateral and equiangular pentagon.
8. Equal triangles which have one angle of the one equal to one angle of the other, have their sides about the equal angles reciprocally proportional; and triangles which have one angle of the one equal to one angle of the other, and their sides about the equal angles reciprocally proportional, are equal to one another.
9. If from the vertical angle of a triangle a straight line be drawn perpendicular to the base, the rectangle contained by the sides of the triangle is equal to the rectangle contained by the perpendicular and the diameter of the circle described about the triangle.
10. If a solid angle be contained by any number of plane angles, these shall be together less than four right angles.
11. The sides AB, AC of a triangle are bisected in P, Q, and BQ, CP intersect in H, prove that the triangle BHC is equal to the quadrilateral APHQ.
12. From the angle A of an acute-angled triangle ABC, a perpendicular is drawn to the opposite side meeting it at D; from the angle B a perpendicular is drawn to the opposite side meeting it at E: show that the straight lines which join D and E to the middle point of AB are equal.
13. ABC is a triangle whose acute vertex is A; show that the square of BC is less than the squares of AB, AC, by twice the square of the line drawn from A to touch the circle on BC as diameter.
14. Find a point within a triangle such that if straight lines be drawn from it to the three angular points, the triangle will be divided into three equal triangles.
15. In a given triangle inscribe a rhombus which shall have one of its angular points coincident with a point in the base, and a side on that base.
16. Each edge of a tetrahedron is equal to the opposite edge: prove that the straight line joining the middle points of two opposite edges is at right angles to both.

July 4, 1870; 2 p.m.—5 p.m.

Rev. Dr. Wrigley.

Arithmetic and Algebra.

1. Define a recurring decimal; and show how to reduce mixed recurring decimals to vulgar fractions.

Express ·790451 as a fraction in its lowest terms.

2. Find the value of
$(4\frac{1}{3} \text{ of } 5\frac{3}{8})-(2\frac{1}{7} \text{ of } 2\frac{4}{5}-\frac{2}{9})+7$; and of
·1125 of a crown + ·084375 of a sovereign + 2·36875 of £4.
3. Divide the square root of ·00093636 by ·255.
4. An engine of 15-horse power can pump out $\frac{3}{5}$ths of the water contained in a pit 56ft. deep by working eight hours a day for nine days. In how many days of twelve hours could an engine of 16-horse power perform the remainder of the work?
5. A sovereign weighs $\frac{160}{623}$ of an ounce troy; how many sovereigns may be coined out of a piece of metal weighing 1lb. troy. This metal being composed of eleven parts of pure gold to one part of alloy, what is the value (expressed in money) of an ounce of pure gold?
6. How much stock at $92\frac{2}{3}$ must be sold out to pay a bill of £715 17s. due nine months hence at 4 per cent. interest?
7. If oranges are bought at 8d. a dozen, and retailed at the rate of seven for 6d., what is the gain per cent? and what profit will there be on the sale of fifty-six dozen?
8. Divide $a^3 - b^3 + c^3 + 3abc$ by $a - b + c$; and prove that $(a^2 + b^2 + c^2)(x^2 + y^2 + z^2) - (ax + by + cz)^2 = (ay - bx)^2 + (bz - cy^2) + (cx - az)^2$.
9. Show that

$$\frac{a^2}{(a-b)(a-c)} + \frac{b^2}{(b-c)(b-a)} + \frac{c^2}{(c-a)(c-b)} = 1.$$

10. Extract the square root of

$$\frac{9}{4}a^3 - 5a^{\frac{5}{2}}b^{\frac{1}{2}} + \frac{179}{45}a^2 b - \frac{4}{3}a^{\frac{3}{2}}b^{\frac{3}{2}} + \frac{4}{25}ab^2;$$ and prove that

$$\frac{4}{\sqrt{(8+4\sqrt{3})}} - \frac{1}{\sqrt{(11-2\sqrt{30})}} + \frac{3}{\sqrt{(7-2\sqrt{10})}} = 0.$$

11. Solve the equations:—

(1) $\frac{7x+5}{3} - \left(2x - \frac{3x-7}{14}\right) = 5.$

(2) $\frac{a}{z} + \frac{b}{y} = 1,\ x + y + z = 2c,\ \frac{b}{y} + \frac{z-c}{x} = 0.$

(3) $\frac{x^2 - 5x}{x+3} = x - 3 + \frac{1}{x}.$

(4) $(x+1)^2 = x + 3\sqrt{(3x^2 + 3x - 11)}.$

(5) $\begin{cases} xy(x+y) = 12x + 3y \\ xy(4x + y - xy) = 12(x + y - 3), \end{cases}$

12. Find the positive and integral solutions of

$$13x + 16y = 970.$$

13. If four quantities are proportionals, and the second is a mean proportional between the third and fourth; the third will be a mean proportional between the first and second.

14. Sum the series

(1) $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{6}$, ... to 7 terms.

(2) 3, $2\frac{1}{3}$, $1\frac{22}{27}$, ... to 5 terms, and to infinity.

15. Find a third proportional to the harmonic mean between 6 and 14, and the geometrical mean between 9 and 16.

16. A boat's crew consists of eight men, three of whom can only row on one side and two only on the other. Find the number of ways in which the crew can be arranged.

17. Expand by the binomial theorem.

$$(2a^2 - 3x^3)^5 \text{; and } \sqrt{\frac{1}{(a^2 - x^2)}} \text{ to five terms.}$$

18. A large vessel is filled with a mixture of spirit and water, in which there is found to be 13 per cent. by measure of spirit; ten gallons are drawn off, and the vessel is filled up with water; there is then found to be $11\frac{5}{9}$ per cent. of spirit. Find the contents of the vessel.

(To be continued).

THE ROYAL AGRICULTURAL SOCIETY'S SHOW AT OXFORD.

It is many years since Oxford has been honoured by the presence of the Royal Agricultural Society, although as a central rendezvous for farmers and others interested in such exhibitions, but few cities in England can compare with it. As a natural consequence the show was remarkably successful, although it must be confessed that of all hot places in England in this hot weather, there could not possibly be one to equal it. The approach to the yard, too, which was about a mile from the town, was made as inconveniently as possible, in fact it appeared to have been put up on the Banting principle of reducing one's fat in the shortest possible time. When however the show was reached it amply compensated for the trouble of getting there; the machinery exhibited being with some few exceptions, the best that has ever been brought together. As the show was held so late in the month, it is impossible to give a detailed account in the present issue of The Artizan of all the various machines of merit; we will, therefore, give some of the results of the trials of the engines, and also of the awards of the judges in the machinery department.

The following is a list of the awards of the judges in the various departments connected with machinery.

Section I.—Fixed Steam Engines.

Class 1.—For the class of fixed steam engines of 4-horse-power, with boiler combined, £20. Clayton and Shuttleworth, £9; Brown and May, £6; Reading Ironworks Company, £5; Marshall, Sons, and Co., highly commended; Robey and Co., and Davey, Paxman, and Davey, commended.

Class 2.—For the class of fixed steam engines of above 4-horse-power, and not exceeding 10-horse-power, to be worked by an independent boiler, £30. Clayton and Shuttleworth, £11 5s.; Reading Ironworks Company, £11 5s.; Marshall, Sons, and Co., £7 10s.

Section II.—Horse Gears.

Class 1.—For the class of gears for one horse, £10. Woods, Cocksedge and Warner, £5; Richmond and Chandler, £2 10s.; R. Hunt, £2 10s.; Hunt and Pickering, highly commended; Coleman and Morton, T. Corbet, and Reading Ironworks Company commended.

Class 2.—For the class of gears for two horses, £10. Woods, Cocksedge, and Warner, £5; E. R. and F. Turner, £2 10s.; Richmond and Chandler, £2 10s.; R. Hunt, and Mellard's Trent Foundry Co., highly commended; Coleman and Morton, Woods, Cocksedge and Warner, T. Corbet, and Williamson Bros. commended.

Section III.—Mills,

Class 1.—For the class of mills, with stone grinders, for grinding agricultural produce into meal, by steam or horse-power, £20. John Weighell, £8; E. R. and F. Turner, £7; Marshall, Sons, and Co., £5; Reading Ironworks Company, commended.

Class 2.—For the class of mills, with metal grinders, for grinding agricultural produce for feeding purposes, by steam or horse-power, £20. Amies, Barford, and Co., £8; Thomas Corbett, £7; E. and H. Roberts, £5; Smith and Grace, commended.

Class 3.—For the class of mills, with metal grinders, for grinding agricultural produce for feeding purposes, by hand power. The judges do not recommend any award in this class.

TABLE I.—Fixed Engines with Boilers Combined.

Reference Number.	Makers' Name.	Class.	Nominal Power Maker's Rule.	Size of Cylinders. Diameter.	Size of Cylinders. Stroke.	Average Dynametrical Horse Power developed during trial.	Nominal Speed of Engine in Revolutions per Min.	Average Speed of Engine during Trial in Revolutions per Min.	Average Speed of Piston, in Feet, per Minute.	Actual Time Run.	"Mechanical Time" Run = total number of Revolutions ÷ by Nominal Speed.	Period of Admission of Steam in parts of the Stroke.	Consumption of Coals per Dynametrical Horse Power, per hour.	Duty per bushel of 84lbs.
					in.					hrs. min.	hrs. min.		lbs.	
1	Clayton and Shuttleworth, Lincoln	Horizontal	4	7	12	4·42	110	121·6	243·2	3 24	3 45	...	3·73	44,602,320
2	Brown and May, Devizes	"	4	$7\frac{3}{16}$	1[illegible]	4·19	120	125·65	251·3	3 $0\frac{1}{2}$	3 9	$\frac{11}{48}$	4·44	37,305,576
3	Reading Iron Works Company Reading	"	4	$5\frac{3}{4}$	14	4·16	140	145·7	340·1	2 54	3 1	...	4·65	35,728,812
4	Marshall, Sons, and Co., Gainsborough	Vertical	4	$7\frac{1}{4}$	12	4·51	110	124·0	248·0	2 $9\frac{1}{2}$	2 26	$\frac{1}{4}$	5·75	29,066,856
5	Robey and Co., Lincoln	"	4	$7\frac{1}{4}$	12	4·506	120	135·18	270·36	2 $6\frac{1}{2}$	2 $22\frac{1}{2}$	Variable	5·9	28,173,936
6	Davey, Paxman, and Davey, Colchester	"	4	$6\frac{3}{4}$	12	3·98	115	114·6	229·8	2 21	2 20	$\frac{1}{7}$	6·0	27,666,996
7	Ashby, Jeffery, and Luke, Stamford	"	4	$6\frac{3}{4}$	10	...	150	...	...	2 13	2 $15\frac{1}{2}$	about $\frac{3}{10}$	6·02	26,854,052
8	Riches and Watts, Norwich	"	4	$6\frac{1}{2}$	10	4·25	150	159·37	265·6	2 0	2 $7\frac{1}{2}$	$\frac{4}{10}$	6·58	25,228,392
9	Hancock and Foden, Sandbach	"	4	7	12	4·33	120	130·0	260·0	1 29	1 $36\frac{1}{2}$	...	8·7	18,862,872
10	W. N. Nicholson, Newark	"	4	$6\frac{3}{4}$	12	3·4	100	89·0	178·0	1 1	0 $54\frac{1}{3}$	...	15·1	10,739,140
11	T. D. Eagles, London	"	4	$6\frac{1}{2}$	10	3·87	100	96·9	161·5	0 31	0 30	...	28·0	6,021,372

TABLE No. II.—Fixed Engines.

Reference Number.	Makers' Name.	Class.	Nominal Power Maker's Rule.	Size of Cylinders. Diameter.	Size of Cylinders. Stroke.	Average Dynametrical Horse Power developed during trial.	Nominal Speed of Engine in Revolutions per Min.	Average Speed of Engine during Trial in Revolutions per Min.	Average Speed of Piston, in Feet, per Minute.	Actual Time Run.	"Mechanical Time" Run = total number of Revolutions ÷ by Nominal Speed.	Period of Admission of Steam in parts of the Stroke.	Consumption of Coals per Dynametrical Horse Power, per hour.	Duty per bushel of 84lbs.
				in.	in.								lbs.	
1	Clayton and Shuttleworth, Lincoln	Horizontal	10	10	20	11·0	65	71·49	238·3	3 $4\frac{1}{2}$	3 23	Variable about $\frac{3}{10}$	4·14	40,202,484
2	Reading Iron Works Company, Reading	"	10	$8\frac{3}{4}$	20	10·42	105	109·4	364·66	3 11	3 19	$\frac{4}{140}$	4·22	39,475,044
3	Marshall, Sons, and Co., Gainsborough	"	10	$10\frac{3}{4}$	16	10·38	70	72·7	193·9	2 36	2 42	$\frac{3}{10}$	5·2	32,093,208
4	W. S. Underhill, Newport	"	10	$10\frac{3}{4}$	14	9·8	97	95·16	222·05	2 $18\frac{1}{4}$	2 21	About $\frac{1}{3}$	6·02	28,311,108
5	E. R. and F. Turner, Ipswich	"	10	11	18	10·26	105	107·7	323·1	2 17	2 $13\frac{1}{2}$	Variable	6·24	26,978,448

Section IV.—Crushers.

Class 1.—For the class of corn crushers by steam or horse-power, £15. Ransomes, Sims, and Head, £6; E. H. Bentall, £5; Woods, Cocksedge, and Warner, £4; E. R. and F. Turner, commended.

Class 2.—For the class of corn crushers by hand-power, £10, E. H. Bentall, £6; Woods, Cocksedge, and Warner, £4.

Class 3.—For the class of linseed crushers by steam or horse-power, £5. E. R. and F. Turner, £5.

Class 4.—For the class of linseed crushers by hand-power, £10. E. R. and F. Turner, £6; Woods, Cocksedge, and Warner, £4.

Section V.—Chaff Cutters.

Class 1.—For the class of chaff cutters to be worked by steam or horse-power, £20. Richmond and Chandler, £10; E. H. Bentall, £5; Picksley, Sims, and Co., £5; Carson and Toone, highly commended; J. Cornes and Co., and T. Allcock, commended.

Class 2.—For the class of chaff cutters to be worked by hand-power, £10. Richmond and Chandler, £6; Picksley, Sims, and Co., £4; Smith and Grace and E. H. Bentall, highly commended.

Section VI.—Oilcake Breakers.

Class 1.—For the class of oilcake breakers, for large and small cake, to be worked by steam or horse-power, £15. Amies, Barford, and Co., £6; E. R. and F. Furner, £5; Hunt and Pickering, £4.

Class 2.—For the class of oilcake breakers, for large and small cake, to be worked by hand-power, £10. Amies, Barford, and Co., £6; Mellard's Trent Foundry Company, £4; S. Corbett and Son, commended.

Section VII.—Turnip Cutters.

Class 1.—For the class of turnip and root cutters, £17. R. Hornsby and Sons, £7; Hunt and Pickering, £4; R. Hunt, £4.

Section VIII.—Steaming Apparatus.

Class 1.—For the class of steaming apparatus for the preparation of food for stock, £20; Amies Barford, and Co., £12; Amies Barford, and Co., £8.

Section IX.—Dairy Implements.

Class 1.—For the class of churns worked by hand-power, £10; Robert Tinkler, £4; George Hathaway, £3 10s.; Thomas Bradford and Co., £2 10s.; Thomas and Taylor, highly commended; Robinson and Richardson and W. Wade commended.

Class 2.—For the class of churns worked by any other power, £10; Robert Tinkler, £4 10s.; Robinson and Richardson, £3; Thomas Bradford and Co., £2 10s. Special awards for churns adapted to small occupation: Thomas Bradford and Co., £4; Phillip Johnson, £3.

Class 3.—For the class of cheese tubs, £10; Mellard's Trent Foundry, £3 (the judges have withheld the balance of the amount offered for this class).

Class 4.—For the class of cheese presses, £10; Southwell and Co., £4 10s.; Mellard's Trent Foundry, £3; J. Cornes and Co., £2 10s.

Class 5.—For the class of other dairy utensils, £10; J. Cornes and Co., for curd drainer, &c., £2 10s.; Southwell and Co., for curd mills, £2 10s.; Carson and Toone, for cheeseturner and general collection of cheese-making apparatus, £2 10s.; Allway and Son, for general collection of utensils for butter-making, £2 10s.; W. and F. Richmond, milk tankards and improved milk carriages, highly commended; Atmospheric Churn Company, atmospheric churns, highly commended.

Section X.—Bone Mills.

Class 1.—For the class of bone mills to be worked by steam or other power, £20; Beverly Iron and Waggon Company, £9; Beverly Iron and Waggon Company, £6; W. Crosskill and Sons, £5.

Section XI.—Guano Breakers.

Class 1.—For the class of guano breakers worked by hand-power, £20. The prize is withheld for want of merit.

Section XII.—Coprolite Mills.

Class 1.—For the class of coprolite mills, £10; E. R. and Turner, £10.

Section XIII.—Flax-breaking Machines.

Class 1.—For the class of flax-breaking machines, £10; John Eliot Hodgkin (for steam or horse-power), £6; Jonh Eliot Hodgkin (for hand-power), £4.

Section XIV.—Tile Machinery.

Class 1. For the class of machines for the manufacture of draining tiles, £15; J. D. Pinfold (for steam or horse-power), £8; J. Whitehead (for hand-power), £7; Edward Page and Co. (for hand-power), commended.

Section XV.—Draining Tools.

Class 1.—For the class of draining tools, £10; Hunt and Pickering, £6; Clarke and Son, £4; F. Parkes and Co., highly commended.

Miscellaneous Awards to Agricultural Articles and Essential Improvements Therein.

Ten silver medals:—Amies, Barford, and Co's. portable metal corn-grinding mill. with dressing apparatus; Amies, Barford, and Co, Campains' patent anchors for steam cultivation, W. Barton's cottagers' patent cooking stove, J. and F. Howard's patent self-acting appliance to horse-rake, G. Murray's collection of models for a cheese factory, Pooley and Son's automatic grain scale, Robey and Co's. patent self-feeding apparatus for thrashing machine, J. and B. Sainty's patent wood covering for temporary buildings, &c., James Sinclair's chemical fire engines, Robert Mayuard's patent portable steam-power chaff-siftiug engine. Highly commended:—Amies, Barford, and Co's. steam cooking apparatus, T. Baker's tip cart, W. Ball aud Son's patent double brake on wagon, Barrows and Stewart's improved windlass for steam cultivation, Beverly Iron and Waggon Company's self-acting sheaf delivery to reaping machine, Thomas Corbett's improvement in hand clover seed barrow, James Davey's improved cart harness, J. Fowler and Co's. traction engiue on springs, Hart and Co's. self-registering corn-weighing machiue, Holmes and Sons' improvement in hay and corn elevator, Hornsby and Sons' combined corn-dressing and screening machine, T. Hunter's Dickson's patent double-drill turnip-cleaner, T. McKenzie aud Son's reaper and mower knife-grinder, G. W. Murray and Co's. combined double-furrow plough and subsoiler, Thomas Perkins' pateut folding shafts for reaping and mowing machines, Rainforth and Son's improved patent corn screen, Richmond and Chandler's litter cutter, J. B. Saiuty's imporved cattle crib, Southwell and Co's. improvement in ridging plough, William Smith's sheep rack, R. W. Thompson's patent road steam engine.

Commended.

J. P. Barford's improved carriage jack, Henry Deuton's improvement in a chain harrow carriage, McKenzie and Son's improvements in turnip and mangold drill, H. J. and C. Major's roofing tiles, J. and B. Sainty's improvements in field gate, J. and B. Sainty's sheep fencing, R. Winter's machine for tarring sheep-fold netting.

Obituary.

MR. GEORGE ENGLAND.

We regret to announce the death of Mr. George England, who has survived his father, the well-known locomotive engineer of Hatcham Iron Works for only about a year. To the late firm, our readers will remember that we were indebted for several most interesting examples of locomotive work, amongst others we may mention the "pony" locomotives for the mineral traffic of the Festiniog Railway. The subject of our notice was only in his twenty-sixth year, his death being very unexpected, as a few days previously he was in comparative health. Since the works at Hatcham were transferred to Mr. Robert Fairlie he continued to take an active part in their management, and from his kindly and genial disposition was a universal favourite.

NOTES AND NOVELTIES.

MISCELLANEOUS.

A Diving apparatus, on a large and very complete scale, is in course of shipment by the P. and O. route to Singapore. The want of such an apparatus has long been felt in the straits, and much valuable cargo, and even vessels will now be recovered. With the numerous losses which occur in the neighbouring straits and passages in the China and Java seas, there will be ample employment. The machine will be fitted up on a vessel, and worked under the charge of Messrs. Harrison, Smith, and Co.

A New Photometer.—A photometer, invented by M. Nagant, is based upon the formation of of a column of liquid, partially opaque, which may be drawn out until the length is such that the light from an illuminating body ceases to be visible through the liquid. The length of the column, which completely obscures the light, starting from the point where the column is thinnest, gives a measure of the intensity of the light under examination.

Welch's patent preservative and anti-fouling cements for the bottoms of iron ships, after lengthened and severe trial by the Admiralty, are pronounced successful.

Tessie du Motay has discovered a new blue pigment, the chief novelty of which consists in its containing tungsten. It is prepared by dissolving in water ten parts of tungstate of soda, eight of chloride of tin, six of ferro-cyanide of potassium, and one of perchloride of iron. The mixture is well stirred and the pasty sediment separated by filtration and dried in shallow dishes. The pigment much resembles Prussian blue, but resists the action of light far better. It is sold at the same price as the best quality of Prussian blue.

LAUNCHES

On the 27th June, Messrs. R. Napier and Sons launched from their building yard at Govan an iron screw spar-deck steamer, built to the order of Messrs. Shaw, Maxton, and Co., London, and intended for the East India and China trade. Her principal dimensions are:—Length, 320ft.; breadth, 37ft. 9in.; depth, 31ft.; tonnage, B.M., 2,250 tons; engines, compound, 240 nominal horse-power. The *Lord of the Isles* is the first vessel built on the Clyde under the new rules recently adopted by Lloyd's committee, being classed 100 A by the new designation.

Glasgow.—On the 30th June, Messrs. Alex. Stephen and Sons launched from their works at Kelvinhaugh a fine three-decked iron screw steamer, for Messrs. John Warrack and Co., Leith, of 1,400 tons, and 95 A at Lloyd's, built under a roof, and fitted with compound engines of the newest description, of 170 horse-power, by Messrs. Howden and Co. The vessel is to be employed in the Eastern trade, *via* Suez Canal. The ceremony of naming her the *Atholl* was performed by Mrs. Warrack, Glasgow. There was launched on the same day from the west shipbuilding yard of Messrs. Charles Connell and Co., at Overnewton, a finely-modelled composite sailing ship, of 1,235 tons, built to obtain the highest class at Lloyd's, and to the order of Messrs. Sandbach, Finne and Co., Liverpool. She is to be employed in the East India and China trade.

On the 28th of June Messrs. Murray and Co. launched, from their yard at Port-Glasgow, a twin screw steamer of 200 tons for the South American coasting trade. She was towed to Glasgow, where she will be engined by Mr. David Rowan.

There was launched on the 13th ult from Messrs. Caird and Co.'s shipbuilding-yard, a handsome iron screw steamer of 2,245 tons, for the North German Lloyd's company, and named the *King William*. She is of the following dimensions:—Length of keel 300; depth of hold, 32ft.; breadth of beam 39ft. The *King William* was intended for the Bremen, Southampton and West Indies trade, and is the pioneer of several vessels at present under construction for the same firm by Messrs Caird and Co.

On the 25th of June a new screw steamer was launched form the yard of Messrs. T. and W. Smith, North Shields. On the same afternoon a screw-steamer was launched from the building-yard of Messrs. Schlesinger and Davis, Wallsend.

There was launched on the 5th ult. from the building-yard of Messrs. Scott and Company, Greenock, an iron screw steamer named the *Hispania*, of 450 tons and 60 horse-power, built for Messrs. Mories, Munro and Co., Glasgow, for the Mediterranean and general trade. The vessel is supplied with combined high and low pressure engines by the Greenock Foundry Co. She has been coated with the British and Oriental Ship Coating Company's composition for the prevention of fouling.

Launch of an Anchor Liner.—On the 30th of June there was launched from the building-yard of Messrs. Robert Duncan and Co., Port-Glasgow, a very handsome screw-steamer of 1,550 tons register, named *Ismailia* intended as an addition to the Transatlantic fleet of the well-known Anchor Line of Messrs. Handyside and Henderson. The machinery for the *Ismailia*, which is constructed on the compound principle, and intended to ensure a high rate of speed with moderate consumption of fuel, will be supplied by the Finniestou Steamship Works Company, and it is expected a few weeks will suffice to complete her equipment ready for sea.

SHIPBUILDING.

Shipbuilding in the United Kingdom.—From a return just published of the number and tonnage of vessels above 50 tons built at each port of the United Kingdom during the years ending 1867, 1868, and 1869 respectively, it appears that during the past year there were built in England 477 sailing and steam vessels of 202,510 tons; in Scotland 211 vessels were built, of 135,354 tons; and in Ireland 19 vessels, of 9,021 tons.

Shipbuilding at Liverpool.—A paddle steamer built for the City of Dublin Steam Packet Company, and intended to be employed in the conveyance of cattle, was launched on the 25th of June by Messrs. Laird of Birkenhead. Messrs. Laird have now several important operations on hand. The *Spain*, of 4,000 tons, which is being built for the National Steam Navigation Company, is making rapid progress, as are her engines, of 600 horse-power, in the engine shop. In another dock the screw steamer *Macgregor Laird*, belonging to the African Mail Company, is being lengthened. Preparations are being made for another vessel of about 3,000 tons and 550 horse-power for the Pacific Steam Navigation Company. Two screw steamers, of about 900 tons burthen and 110 horse-power, are rapidly growing into frame, and the keel of another, of 1,600 tons burthen and 200 horse-power, is about to be laid. The engines for all these vessels are to be on the compound principle, and are being made at the works, besides several other pairs.

TRIAL TRIPS.

Trial Trip of the "Ægean."—The new screw steamer *Ægean*, just completed by the London and Glasgow Engineering and Iron Shipbuilding Company for Mr. Charles Williamson, Leith, and others, went on her trial trip on June 29th. The dimensions of the *Ægean* are 230ft. by 31ft., 22½ft. hold; gross tonnage about 1,200 tons, with engines, on the builders' compound principle, of the combined power of 150 horses. The performance of the engines and the speed of the ship were of the most satisfactory kind, being nearly 11½ knots on a run between the Lights on a consumption of fuel considerably under 2lbs. per indicated horse-power. The *Ægean* is built to highest class in Lloyd's, and is a sister ship to the *Craigforth*, built by the company last year for the same owners, and whose career has hitherto been most successful.

DOCKS HARBOURS, BRIDGES.

An official communication from the Suez Canal Company states that the curve near Lake Timsah, which was found so inconvenient for the passage of ships, is being removed, and that other curves are being properly buoyed. Twelve vessels passed through the canal from the 1st to the 6th ult. A ship called the *Hermes* has been chartered to load a cargo of cotton and grain at Ismailia for this country.

MINES, METALLURGY, &c.

Messrs. Chatwood and Sturgeon, of Bolton, have patented, and have just tried, a new machine for crushing ores. The inventors believe that they can by this means do all the work of the old crushing apparatus more effectually at one-sixth the cost of plant.

APPLIED CHEMISTRY.

Experiments have been made in the laboratory of the University of Munich to determine the extent to which the power of illuminating gas is affected by temperature, whilst that of air, which supplied oxygen for combustion, was not changed. The illuminating power of the gas at 64½ deg. Fah. being accounted 100 as the standard, it was found that when the gas was reduced in temperature, by applying cooling mixtures to the tube through which it passed to 32 deg., its average illuminating power was 80 deg.; and on reducing its temperature to 4 deg. Fah. its illuminating power was, in some cases, 33, or about one-third of its power at the standard. On the other hand, by raising the temperature of the gas to 212 deg. Fah., its illuminating power was found to be 104, and on increasing its temperature to 280 deg. Fah. the illuminating power was found to be 118.

WATER.

Singapore Water Supply.—The question of a water supply for the town of Singapore is still undecided, but will, we understand, come on for discussion at the meeting of the Legislative Council in the present month. Mr. E. J. Wells, the manager of the Singapore Gasworks, now in London, has, we believe, sent out to the Municipal Council fresh estimates for works capable of supplying 1,500,000 gallons daily at a total cost of 166,000 dols., under the high pressure and gravitation system. All attempts on the part of the Government to obtain a supply of water having failed it is hoped that the matter will be left in the hands of the Municipal Council. With the settlement of this question we hope some plan will be decided on for connecting the new harbour with the town by means of a tram or railway, which would not only remove the present slow, dirty and intolerable means of conveyance for both passengers and goods, but improve the condition and value of the land *en route*. At present the road is most offensive, and sadly mars the natural beauties of the neighbourhood. We may add, it is a disgrace to Singapore.—*London and China Express.*

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	s.	d.		s.	d.
COPPER.						
Best selected, per ton	75	0	0	,,	,,	,,
Tough cake and tile do.	73	0	0	,,	,,	,,
Sheathing and sheets do.	76	0	0	78	0	0
Bolts do.	77	0	0	,,	,,	,,
Bottoms do.	78	0	0	,,	,,	,,
Old (exchange) do.	69	0	0	,,	,,	,,
Burra Burra do.	69	0	0	71	0	0
Wire, per lb.	0	0	10	,,	,,	,,
Tubes do.	0	0	11	,,	,,	,,
BRASS.						
Sheets, per lb.	0	0	8¼	0	0	0
Wire do.	0	0	7¼	,,	,,	,,
Tubes do.	0	0	10	,,	,,	11½
Yellow metal sheath do.	0	0	6½	0	0	7
Sheets do.	0	0	6½	,,	,,	,,
SPELTER.						
Foreign on the spot, per ton	19	10	0	,,	,,	,,
Do. to arrive	,,	,,	,,	,,	,,	,,
ZINC.						
In sheets, per ton	24	0	0	,,	,,	,,
TIN.						
English blocks, per ton	130	0	0	0	0	0
Do. bars (in barrels) do.	131	0	0	0	0	0
Do. refined do.	134	0	0	,,	,,	,,
Banca do.	120	0	0	122	0	0
Straits do.	120	0	0	,,	,,	,,
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	6	6	1	8	0
IX. do. 1st quality do.	1	12	6	1	13	6
IC. do. 2nd quality do.	1	6	0	1	6	6
IX. do. 2nd quality do.	1	12	0	1	12	6
IC. Coke do.	1	3	0	1	3	6
IX. do. do	1	9	0	1	9	6
Canada plates, per ton	13	10	0	14	10	0
Do. at works do.	13	0	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	7	6	7	10	0
Do. to arrive do.	7	5	0	7	10	0
Nail rods do.	7	10	0	,,	,,	,,
Stafford in London do.	8	5	0	9	0	0
Bars do. do.	8	0	0	9	0	0
Hoops do. do.	8	15	0	9	0	0
Sheets, single, do.	9	10	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	0
Bars, common, do.	6	15	0	7	0	0
Do. mrch. Tyne or Tees do.	6	10	0	,,	,,	,,
Do. railway, in Wales, do.	7	10	0	7	15	0
Do. Swedish in London do.	9	10	0	9	15	0
To arrive do.	9	12	6	,,	,,	,,
Pig No. 1 in Clyde do.	2	12	0	3	0	0
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. No. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	17	0	6	0	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pig in London do.	6	5	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	13	10	0	13	15	0
Do. (hammered) do.	14	5	0	14	10	0
Do. in faggots do.	15	10	0	,,	,,	,,
English spring do.	17	0	0	23	0	0
Quicksilver, per bottle	7	17	0	,,	,,	,,
LEAD.						
English pig, common, per ton	19	10	0	20	0	0
Ditto. L.B. do.	19	15	0	20	0	0
Do. W.B. do.	20	10	0	20	15	0
Do. sheet, do.	20	10	0	,,	,,	,,
Do. red lead do.	20	10	0	21	0	0
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	22	0	0	,,	,,	,,
Spanish do.	19	5	0	19	10	0

*At the works 1s to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated June 23rd, 1870.

1790 A. Barclay—Smelting ores
1791 R. Hudson—Cloth
1792 E Finch—Forcing or exhausting air or aeriform fluids
1793 W. R. Lake—Improved faucet

Dated June 24th, 1870.

1794 A. Ruiz and E. Le Pelletier—Revolving coilers
1795 C. Stephens—Boot trees
1796 W. Brown—Hydraulic rams used in naval warfare
1797 P. Jensen—Indicating the speed of vessels and the velocity of running water
1798 J. Smith—Spinning or doubling fibrous substances
1799 A. and J. Stewart—Welded iron
1800 J. Sinclair—Respiratory apparatus
1801 S. F. V. Choate—Distilling
1802 G. Ritchie—Sunshades
1803 T. Wrightson—Lowering weights

Dated June 25th, 1870.

1804 R. Saunders—Breakwaters
1805 J. and B. Shackleton—Paper tubes for use in spinning machinery
1806 G. Thomson—Treating manganese ores
1807 S. J. and Edgar—Levelling fryingpans
1808 J. Sax—Mechanical recorder
1809 S. Norris and T. Griffiths—Mixing and kneading dough
1810 J. Napier and W. Cruickshank—Portable bath
1811 W. Martin—Woven gauze fabrics
1812 E. Lambert—Iron stages
1813 E. V. de Forville—Velocipedes

Dated June 27th, 1870.

1814 R. Morton—Cooling liquids
1815 D. Rowan—Valves
1816 H. A. Bonneville—Ventilating carriages and boats
1817 J. Clarke—Radiating the axles of locomotive axles
1818 V. Rastouin—Steam engines
1819 W. E. Gedge—Drilling
1820 J. G. H. Hill—Elastic stockings
1821 W. E. Newton—Production of sugar
1822 W. B Adamson—Artificial stone
1823 R. Kell—Treating petroleum
1824 J. Butterworth and J. B. Hutchinson—Carriage wheels
1825 J. Butterworth and J. B. Hutchinson—Wooden skewers
1826 E. W. Sandford—Friction brake
1827 W. R. Lake—Rails for railways
1828 W. Riddell—Cutting wood
1829 W. R. Lake—Breech loading firearms
1830 W. Bull—Conveyance of plants
1831 W. R. Lake—Candles
1832 C. McDermott—Pencils for marking linen

Dated June 28th, 1870.

1833 D. Male—Clip adjustments of door springs or hinges
1834 S. Hampson and J. Higson—Mowing and reaping machines
1835 J. F. Hoffgaard—Pipes for smoking
1836 C. J Carr—Horseshoes
1837 J. Weatwood and R. Baillie—Construction of ships
1838 A. Metcalf and W. Gibbons—Strapping motion in mules for spinning
1839 J G. H. Hill—Fans
1840 T. P. and D. Miller—Dyeing yarns
1841 T. Corbett—Ploughs
1842 W. J. Clarke—Frames for photographs
1843 A. M. Clark—Steam generators
1844 W. R. Lake—Hulling coffee and rice
1845 H. Medlock—Separating aqueous from oleaginous substances

Dated June 29th, 1870.

1846 F. Caillieux—Eccentric paddle wheels of every description
1847 G. C. Davies—Wood screws
1848 R. G. Brewer—Preserving animal and vegetable substances
1849 S. Norton—Combined hydraulic filter and double valve tap
1850 J. Lightbody—Drying machine
1851 G. S. Lee—Metallic jogs
1852 S. Duer—Steam boilers
1853 W Spence—Copying presses
1854 W. R. Lake—Delivery of mail bags to railway trains in motion

Dated June 30th, 1870.

1855 A. Guattari—Telegraphy
1856 W. R. Lake—Steam generator and in furnaces therefore
1857 W. R. Lake—Chlorinating ores
1858 C. Topham—Washing and removing the skins of potatoes
1859 J. Bourne—Producing and regulating motive power
1860 G. Little—Moulding for casting
1861 J. L. Clark—Telegraph instruments
1862 H. Hodgkinson—Velocipedes
1863 R. Pickney—Producing colours from aniline
1864 C. N. May—Furnaces

Dated July 1st, 1870.

1865 J. Hynam and J. Dixon—Manufacture of friction lights
1866 A. M. Clark—Producing ice
1867 W. R. Lake—Boat detaching apparatus
1868 J. Hosken—Masthead lights
1869 H. Airy—Ornamenting paper
1870 W. P. Ayres—Arrangement of horticultural and other buildings
1871 J. A. McIntosh—Distilling oils
1872 T. Gray—Purification of gas

Dated July 2nd, 1870.

1873 J. H. Johnson—Dressing stones to be employed for decorticating grain
1874 R. McHardy—Harnessing horses
1875 E. Stevens—Kneading flour
1876 F. Johnston and I. Bradshaw—Looms for weaving
1877 J. W. S. Watkin—Measuring distances
1878 O. Reynolds—Propelling ships
1879 T. Rose and R. E. Gibson—Raising paper making materials from revolving boilers
1880 W R. Lake—Axle boxes
1881 S. Corbett—Cutting vegetables
1882 C. Holcroft—Mine cages
1883 G. Scott and H. Young—Measuring the flow of liquids

Dated July 4th, 1870.

1884 E. C. Stiles—Cutting millstones
1885 E. Stevens—F. L. Rovedino and H. Boucher—Fire lighters
1886 H. Blandy—Preserving letters, &c.
1887 T. Broughton and W. Riley—Twisting wool, &c.
1888 J. Shanks—Discharging steam and air from steam pipes
1889 A. Marriott—Regulation of boilers for heating purposes
1890 W. E. Newton—Production of ice
1891 B. Quick and E. N. Norminton—Construction of carriages
1892 M Cahen—Absorbing sulphurous fumes
1893 W. E. Gedge—Frames for portmonnaies
1894 F. Pulman—Marking games

Dated July 5th, 1870.

1895 T. Carr—Cleaning and reducing seeds into flour
1896 E. Holden—Preparing wool
1897 J. Heaton—Obtaining motive power
1898 E. L. Macdonell—Facilitating the traction of wheel carriages
1899 R. A. Novare—Morse telegraph printing apparatus
1900 J. H. Johnson—Evaporating and boiling or concentrating liquids
1901 T. Hydes and W. Wigfull—Connecting hurdles and fencing
1902 J. W. Hoffman and F. A. Harrison—Buttons, &c.
1903 E. T. Hughes—Caustic soda

Dated July 7th, 1870

1904 W. R. Lake—Separating and reducing iron and iron ores
1905 G. Burney and C. Iugall—Storing inflammable liquids
1906 J. Young—Lamps
1907 J. Robertson—Making tubes
1908 A. Prince—Soldiers' litters
1909 J. Bourne—Cutting various substances
1910 L le C Cottam—Spiral staircases
1911 F. R. Eosor—Lace
1912 H. M. Ward—Spinning and twisting fibrous substances
1913 J. Ascough—Venetian blinds
1914 W. R. Lake—Furnaces
1915 F. Tommasi—Submarine hydro electric telegraph cable

Dated July 7th, 1870.

1916 F. J. Liger—Building of ironwork walls
1917 E. L. C. d'Ivernois—Means for producing electric light
1918 A M. Clark—Smoothing irons
1919 C. F Falck—Refrigerator
1920 J. J. McGrath—Construction of wheels
1921 I. Whitesmith—Looms
1922 B. Dobson, T. Thornley, and J. Settle—Cleaning rollers of machines
1923 W. R. Lake—Fastening tickets upon woven goods
1924 T. Read—Reaping machines
1925 D. Lord—Shedding warps in the process of weaving
1926 C Hulste—Pots or crucibles used in glass furnaces
1927 H. H. Murdoch—Combination locks
1928 C. de Bergue—Punching metal
1929 H. J. Crockett—Casement fasteners
1930 D. Gordon—Churning
1931 J. Hensman and W. Armstrong—Agricultural drills
1932 R. Edwards—Interlaying and interlacing of papers with thread
1933 G. G. Bossey—Substitute for bird trap shooting
1934 F. W. Roberts—Preserving the fronts or edges of stays

Dated July 8th, 1870.

1935 J. Buchanan and S. Vickers—Kilns
1936 P. Chaplin—Wheels
1937 R. Hutchison—Bleaching vegetable and animal oils
1938 J. Kershaw—Looms for weaving
1939 W. R. Harris—Connecting wheels
1940 A. Pierre and Count Sparre—Breech loading firearms
1941 A. Cochrane—Giving motion to ships and other floating bodies
1942 W. G. Jackson—Manufacture of cordials
1943 W. R. Lake—Buckles for fastening dress, buckles, &c.
1944 W. R. Lake—Locking and releasing nooks

Dated July 9th, 1870.

1945 T. T. Chellingworth—Hot air engine
1946 H. E. Pavy—Granaries
1947 T. Bruce—Forcing apparatus for hydraulic presses
1948 E. Leahy—Portable railways
1949 P. Spence—Treatment of sewage
1950 D. Nicholl—Waterproof fabric
1951 Sir C H. Pennell—Skates
1952 W. Marriott—Iron compounds and purification of gas
1953 J. P. Barford—Carriage jacks and other lifting jacks
1954 M. H. Wiley—Oil cabinets
1955 G. T. Bousfield—Warp tension and let-off mechanism for power looms

Dated July 11th, 1870.

1956 T. Holcroft—Nails
1957 J. Crossley—Looms
1958 P. D. Hedderwick—Counting paper in sheets
1959 E. Holborrow—Window sash fasteners
1960 J. T. Griffin—Mowing machines

Dated July 12th, 1870.

1961 A. Gilbey—Glass orchards
1962 W R. Lake—Moulding bricks
1963 W. Goreham—Cement
1964 J. Butcher—Fountain pens
1965 G. F. Griffin—Permanent way of tramways and railways
1966 R. J. Scott—Prevention of priming in steam boilers
1967 B. Hunt—Carburetting gases
1968 J. W. McCarter—Condensers for steam engines
1969 N. C. Maximos—Drying malt
1970 R. Long—Continuous self-wedging fencing
1971 J. Frearson—Screws and screwdrivers
1972 S Putney—Apparatus to be worn by railway travellers for lessening the effects of vibration on the spine and nervous system
1973 J A. Coffey—Roasting coffee
1974 D. A. Fyfe—Paper

Dated July 13th, 1870.

1975 C. Mosely—Construction of indiarubber cushions for billiard tables
1976 W. Cowley—Forcing air
1977 W. J. Schlesinger—Washing crockery
1978 W. H. Horsfield—Knife steel
1979 W. Newell—Cleaning coffee
1980 H. Kesterton—Iron tubes
1981 J. H. Johnson—Carpets
1982 W. A. Whitty and H. Chatteris—Registering the arrival of workmen

Dated July 14th, 1870.

1983 W. Spence—Steam generators
1984 J. Redford—Looms
1985 J. Abercrombie—Lubricator
1986 J. W. Ayres—Improving the fastenings of doors, &c.
1987 G. Scoucia—Reducing hard material to fixed patterns
1988 W. E. Newton—Indicators applicable to various purposes
1989 J Humphrys—Steam engines
1990 W. R. Lake—Spools
1991 W. Brown—Screw propellers
1992 C. J Curtis and C. A. Fiddes—Fireproof compositions for safes
1993 H. M. Nicholls—Printing machines
1994 H. Wilson—Cooling and heating liquids
1995 A. Wenner—Firebars
1996 T. Holliday—Extracting water or other liquids from clothes
1997 J. H. Johnson—Bearing surfaces
1998 C. M. Barker—Steam generators

Dated July 15th, 1870.

1999 W. E. Gedge—Incorporating metal and cement in the construction of horticultural tanks, boxes, &c.
2000 H. W. Hammond—Moulding clay into drain pipes
2001 G. and E. Ashworth—Cards employed in carding cotton
2002 R. Scholefield—Making bricks
2003 T. R. Fox—Rigging of ships
2004 J. Rossell—Furnaces
2005 A. Maw—Preparation of clay for earthenware goods
2006 H. Muir and J. Caldwell—Purchase capstans
2007 M. Johnson—Ploughs
2008 J. Wakefield and D. McDowell—Tyres for
2009 H. Baines—Repairing railway rails
2010 R. Dudgeon—Rotary engines

Dated July 16th, 1870.

2011 W. Husband—Pneumatic hammers
2012 N. J Amies—Braiding machines
2013 J. Spiller—Manufacture of flour
2014 A. Jackson—Supplying water to boilers
2015 P. A. Blondel—Lamp for burning mineral oils
2016 S. Tuddenham—Ornamental metal work
2017 G. Hartley—Securing boot tabs
2018 H. G. Avery—Stay busks

Dated July 18th, 1870.

2019 A. Jack—Digging potatoes
2020 H. Ramsden—Ships' logs
2021 S. G. A. Terry—Preparing finings for fining beer
2022 W. Roberts—Weighing machines
2023 J. Walker—Bolts
2024 W. S. Bentley and W. Isbam—Purification of gas
2025 C. Samuel—Announcements for advertising purposes

Dated July 19th, 1870.

2026 R. Sellar—Ploughs
2027 W. E. Wimby—Rails and chairs for railways and tramways
2028 J. F. Parker and E. Sunderland—Melting iron and steel
2029 J. Hull and G. Hibbert—Printing on floor cloths, &c.
2030 J. E. Hughes—Formation of roadways
2031 W. Owen—Wheels
2032 H. M. Ramsay—Treatment of sewage
2033 C. H. and W. Plowright—Applying motive power
2034 S. Norton—Valve taps
2035 J. N. Paxman and H. M. Davey—Construction of boilers
2036 J. Henderson—Iron

Dated July 20th, 1870.

2037 J. Dyus and G. J. Parry—Locks
2038 A. L. Taylor—Circulating fresh air in horticultural buildings
2039 J. A. Mason and J. Williams—Sewing machines
2040 W. M. Ross—Propulsion engine
2041 H. Redfern—Valves for supplying water to tanks
2042 W. Hoggett—Ventilation
2043 J. E. Makins—Spring fastening for carriage and other windows
2044 W. Robinson—Iron
2045 T. M. Hopkins—Drying substances impregnated with moisture
2046 J. E. Duyck—Treating oils
2047 J. H. Lloyd—Deodorising and utilising sewage matters
2048 C. Bartholomew—Treating sewage
2049 G. Phillips—Preparing charcoal
2050 A. V. Newton—Sewing machines
2051 W. E. Newton—Mirrors
2052 B. J. B. Mills—Ovens
2053 S T. Baker—Pigeon traps
2054 D. Jones—Door fastenings

Dated July 21st, 1870.

2055 W. R. Lake—Wheels
2056 F. J. Newton and J. Mosley—Jacquard machines
2057 T A. Warrington—Ventilators
2058 W. Creswick—Lubricating the axles of colliery tubs
2059 A. H. Wharton—Carpets
2060 J. Petrie—Washing wool
2061 W. E. Newton—Lamps
2062 J. Mason and A Parkes—Steel
2063 J. J. M. Sills—Portable watercloset
2064 R. T. Shiells—Preserving vegetable matter
2065 J. H. Johnson—Production of sulphuric and other acids
2066 J. H. Johnson—Explosive projectiles
2067 J. Hunter—Softening fibrous substances

Dated July 22nd, 1870.

2068 J. Ashwin and R. Carter—Lockets
2069 H. Howard and T. Taylurson—Positive differential motion
2070 T. Burrell—Marine engines
2071 T. Higgs and J. Elliott—Gas regulators
2072 A. Turner—Elastic fabrics
2073 W. E Newton—Dressing skins

Dated July 23rd, 1870.

2074 W. J. Johnson—Condensing metallic and other fumes
2075 R. Bailey—Ventilating and heating rooms and other places
2076 L. E. Mouline—Reeling silk
2077 H. Dubs and S. G. G. Copestake—Combining railway carriages
2078 E Cowles and P. Brash—Candles
2079 E. Dittrich, F. Mills, and J. Leidhold—Leeds employed in looms
2080 F. J. Baynes—Forks
2081 H. Doulton—Valves
2082 G. Spragnapane—Dyeing or colouring various articles
2083 W. E. Newton—Apparatus for the manufacture of gas
2084 G. C Philcox and T. Saint—Watches, chronometers, &c.
2085 W. L. Mitchell—Looms
2086 B. C. Scott—Rotary engines

Dated July 25th, 1870.

2087 J. B. E. Defontaine—Improvements in dredging machines
2088 W. L. Anderson—Propellers
2089 O. Watch—Improved machinery for pressing matches
2090 P. Schwartz—Preparing the uppers of boots and shoes
2091 H. Atkinson—Swings
2092 J. E. Sherman—Production of iron and steel, &c.
2093 J. Wilkinson—Cleaning and finishing carpet fabrics
2094 T. P. Bayes—Improvements in washing machines
2095 H. Brooks—Stoppers for bottles and other vessels
2096 W. G. Gard—Preservation of meat and other edibles

HEAVY ORDNANCE,

THE PRINCIPLES AND PROCESSES OF ITS CONSTRUCTION.

Fig. 1.

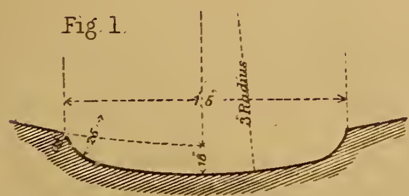


Fig. 3.

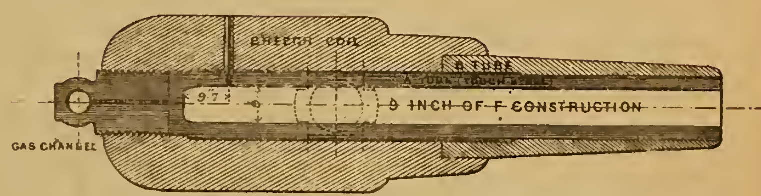


Fig. 2

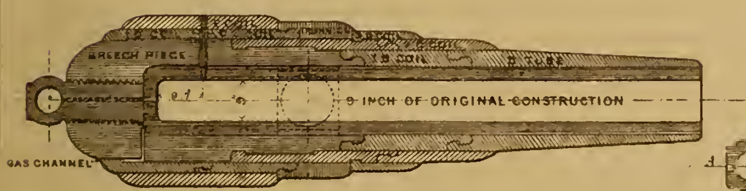
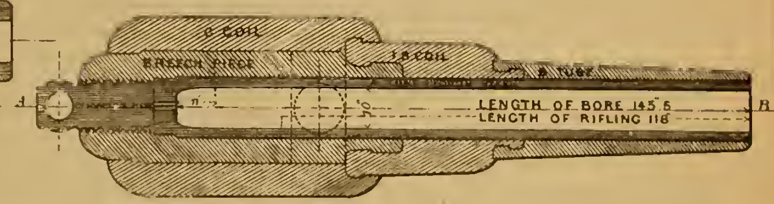


Fig. 4.

WROUGHT IRON MUZZLE-LOADING GUN 10 INCH 18 TONS.



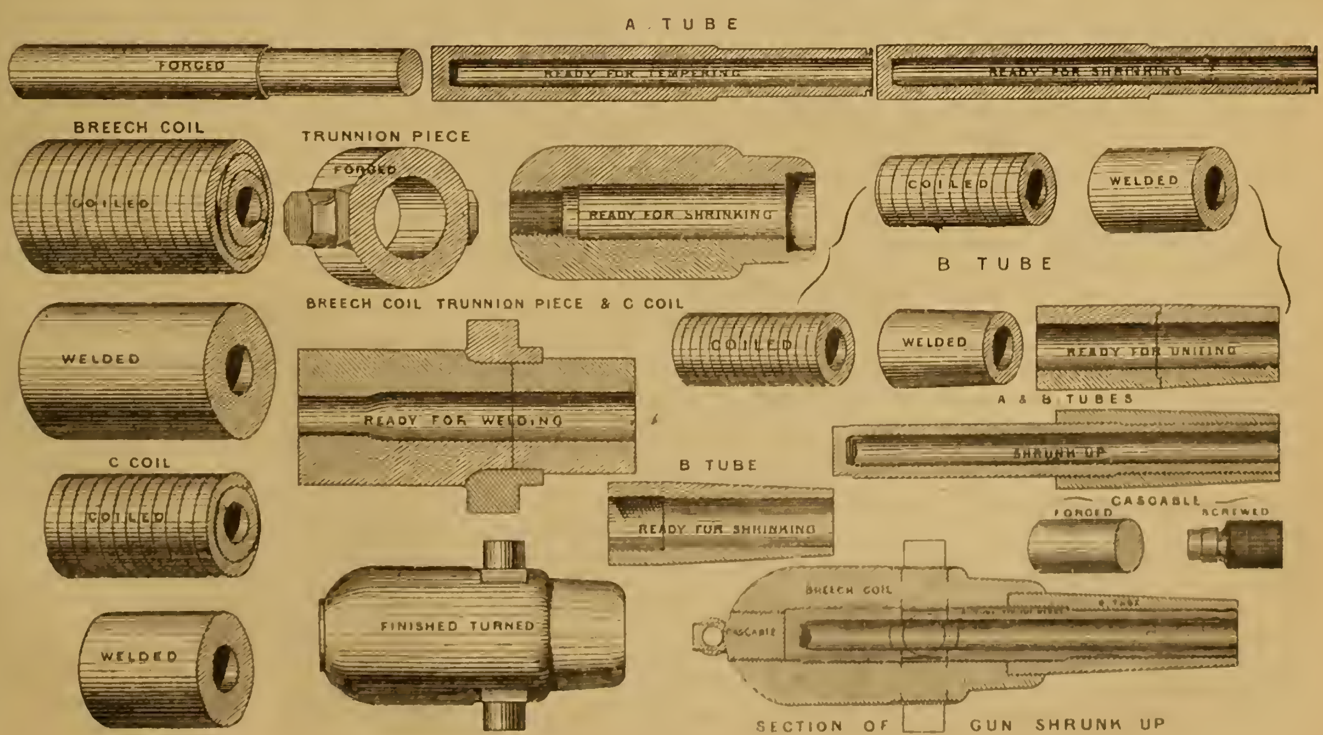


DIAGRAM
to illustrate the most common construction of Woolwich Guns as modified by Mr Fraser.

P. Soames A K C direx.

THE ARTIZAN:

No. 9.—Vol. IV.—Fourth Series.—Vol. XXVIII. From the Commencement.

1st SEPTEMBER, 1870.

THE PROGRESS OF OUR HEAVY ORDNANCE AND THE PRINCIPLES AND PROCESSES OF ITS CONSTRUCTION.

By Captain F. S. Stoney, R.A., Assistant-Superintendent Royal Gun Factories, Woolwich.

(*Illustrated by Plate* 364.)

As the all-absorbing topic at the present time is the condition of our armament, with a view to being in some indirect manner drawn into the present unfortunate war, we have thought it desirable to give to our readers an abstract of an exhaustive paper read before the United Service Institution by Captain F. S. Stoney, R.A.

After a few introductory remarks, the writer began by saying that the subject is one of immense military moment, for of all weapons of war, the big gun is of paramount importance to Great Britain. Continental nations may rely on their infantry breech-loaders, or on their numerous field artillery; but to England, heavy artillery is an absolute necessity of imperial existence; for no one whose mind is not narrowed by regimental prejudices will attempt to deny that our insular country, with its wide spread colonies and extensive commerce, would cease to rule the seas if the Union Jack, afloat and ashore, waved over less powerful guns than those of our neighbours.

The battles of the Nile, Trafalgar, and all the other naval actions about the beginning of this century, were fought and won with no heavier pieces than 68-pounder carronades of 36 cwt., for short ranges, and 32-pounder guns of 56 cwt. If we went to war to-morrow, some of our ships—the *Captain* and *Monarch* to wit—might go into action with 12-inch guns of 25 tons, capable of penetrating any hostile iron-clad afloat at short ranges; or, if distant firing were required, capable of throwing their 600 lb. projectile into a moderately sized magazine two miles away.

The first marked improvement, after Lord Nelson's time, was made about 1830 by General Millar, R.A., the head of the gun factories at Woolwich, who introduced the 8-inch and 10-inch shell guns, for horizontal firing. Ten years afterwards, *i.e.*, in 1840, Mr. Monk, Chief Clerk in the department, proposed the 42-pounders and 56-pounders; and subsequently to this, Colonel Dundas, R.A., who succeeded General Miller, introduced 68-pounders—a great stride, as it was then thought, in the progress of heavy ordnance, and so indeed it was; but the supremacy of the 68-pounder was not of long duration.

When the Crimean war was impending, the general adoption of rifled small arms necessitated the introduction of rifled ordnance, in order that artillery might still retain its superiority over infantry, and remain, as before, the principal arm in the field, which certainly would not be the case if an enemy's skirmishers had the power of placing a battery *hors de combat* before its too-short ranged guns could be brought into action on the advancing columns.

To supply this great want in warfare involved a complete reformation in the architecture of artillery, which had been almost at a standstill since the time of the Tudors; for although modifications had been occasionally made in the manufacture of ordnance, any one who examines the old guns in the Tower of London, or in the Museum of Artillery at Woolwich, may see that they are of the same genus as modern smooth-bores, and even notice some specimens quite as soundly and as artistically cast as any of those of the present century; nay more, he may infer that our modern cast guns can scarcely be superior to their prototypes in range-power, or susceptibility to rifling.

In the lull which succeeded the Crimean campaign, the continental nations turned their attention to the rifled artillery problem. The Emperor Napoleon III. was particularly energetic in the matter, and the French rifled field gun contributed nearly as much to the defeat of the Austrians at Solferino, in 1859, as the Prussian needle-gun did to their defeat at Sadowa seven years afterwards.

Meantime, the Indian mutiny did not prevent our own authorities from carrying on careful and comprehensive experiments with breech-loader rifled guns, on Mr. (now Sir William) Armstrong's system, which he brought first to official notice in December, 1854.

At the same time, extensive experiments were carried on to test whether any safe method of strengthening cast-iron guns could be found, or whether any better, speedier, or cheaper system of constructing rifled ordnance existed than that proposed by Sir William Armstrong. None such having been found within the period for inquiry, the Armstrong system was completely adopted; and in order to obtain a supply of the guns and projectiles as soon as possible, so that we might not be behind other nations, Government not only entered into a contract in January, 1859, with the newly-established Elswick Ordnance Company, but commenced their manufacture in the Royal Arsenal, Woolwich.

Our field artillery was soon furnished with the new field guns, and a goodly number, especially of the larger natures, were, at the urgent request of the Admiralty, supplied to the fleet, and subsequently the whole series of Armstrong guns, from the 6-pounder of 3 cwt. to the 7-inch of 82 cwt., was added to our armaments.

These breech-loaders were used on active service in China, New Zealand, Japan, and Cape Haytien (1866); and although they did not play their part so perfectly well in the heat of action as at their quiet rehearsals at Shoeburyness, their performance, on the whole, was excellent, and fully justified their adoption by the Government. But it is the heavier natures —7-inch and 40-pounders—which most concern now; they were used both at Japan and Cape Haytien, and especially at the latter place, with great success.

Notwithstanding the progressive excellence of his breech-screw guns, Sir William Armstrong introduced not only two natures of wedge-guns (40-pounders and 64-pounders) as an improvement on the breech-screw arrangement, in points of safety and simplicity, but also 64-pounder muzzle-loading guns with shunt rifling, and proposed other shunt guns of larger calibre.

As was natural, however, in this mechanical age and country, Sir William Armstrong was not permitted to bear away the palm without a contest.

Various propositions for rifled guns were submitted to the Ordnance Select Committee, and in 1858 General Peel, the then Secretary of State for War, "called upon Colonel Lefroy, his scientific adviser, for a report on all the experiments that had been tried on rifled ordnance," and in accordance with the recommendation of that report, appointed a Special Committee to examine as to what was the best rifled gun for field service. This Committee came to the conclusion that it was not expedient to incur the expense of trying further experiments with any except those of Messrs. Whitworth and Armstrong.

The trial accordingly took place; but at that time Mr. (now Sir J.) Whitworth did not propose any gun of his own construction, and had only rifled Government blocks of brass and cast iron, the Armstrong breech-loading gun, which was complete in every respect, was, as we have seen, adopted. Nothing daunted, however, Mr. Whitworth carried on a series of private experiments, and having perfected his plans, he obtained such good results with his guns that he again challenged the rival system which the Government had adopted.

A Special Committee was then appointed, 1st June, 1863, to examine and report upon the different descriptions of guns and ammunition proposed by Sir W. Armstrong and Mr. Whitworth.

The inquiry was to embrace the comparative qualities of the several systems with respect to range, accuracy, endurance, ease of working, cost, &c., the fitness, in short, of the guns and ammunition for the various purposes to which ordnance may be applied either on land or sea service.

The Committee accordingly made patient and extensive competitive experiments with Whitworth 12-pounders and 70-pounders, Armstrong 12-pounder and 70-pounder breech-loaders, and Armstrong 12-pounder and 70-pounder muzzle-loaders; the 12-pounders having been chosen to decide the question for field artillery, whilst the 70-pounders were the best available representatives of heavy artillery, comprising siege, garrison, and broadside guns.

The Whitworth guns were muzzle-loaders, and had his well-known hexagonal rifling, and mechanically fitting projectiles.

The 12-pounders were of solid mild steel (having trunnion rings screwed on to them) with a hoop of the same material over the powder chamber.

The 70-pounders were of the same material, but consisted of an inner tube closed by a breech-screw and strengthened by hoops pressed on cold by hydraulic pressure.

Sir William Armstrong, who declared that his system was not limited to breech-loaders, put forward both breech-loaders and muzzle-loaders for competition; both were constructed with steel barrels, and with wrought iron coils superimposed as usual.

After a searching examination of important witnesses, and complete and comprehensive trials, which cost over 30,000*l.* for stores, &c., and which lasted two years and a half, the Committee concluded their labours.

The results of these experiments were very creditable to both inventors, especially as regarded the construction of their respective guns, each of which, after firing about 3,000 rounds, was only burst at last by abnormal means; but the report was, on the whole, most in favour of the Armstrong muzzle-loaders, and among the points of the utmost importance to gunnery, which the Committee established in the course of their experiments, are the following:—

"That muzzle-loading guns can be loaded and worked with perfect ease and abundant rapidity.

"That guns fully satisfying all conditions of safety can be made with steel barrels, strengthened by superimposed hoops of coiled wrought iron, and that such guns give premonitory signs of approaching rupture; whereas guns composed entirely of steel are liable to burst explosively, without giving the slightest warning to the gun detachment."

Necessity for Heavy M.L. Rifled Guns.

It is remarkable the effect which rifled guns had on the science of artillery. Although rifled guns were made more powerful than the smooth-bore 68-pounders, they soon became insufficient for the modern requirements of naval warfare, for the power and precision of rifled guns and the growing use of concussion shells which would burst on striking on a ship's side and make a hole beyond repair, or having penetrated would burst between decks, dealing death and destruction around, and probably setting fire to the vessel, necessitated the use of iron-clads. To penetrate these necessitated in turn still more powerful guns, and then commenced the Shoeburyness campaign of guns *versus* armour plates, which is not yet decided.

The judgment which the Armstrong and Whitworth committee pronounced in favour of muzzle-loading guns was only in accordance—so far at least as heavy guns were concerned—with the preconceived opinion of our leading artillerists, for any breech-loading arrangement with guns using the enormous charges required would not only be too cumbrous but actually unsafe.

As the striking effect of a projectile depends more on its velocity than on its weight, and as a round shot fired from a smooth-bore gun has considerably greater initial velocity than an elongated shot fired from a rifled gun, owing to the friction in the bore of the latter, as well as to its smaller proportionate charge, the Admiralty at first proposed wrought-iron smooth-bore guns of large calibre to penetrate armour-plated vessels at close quarters. Accordingly in 1864, after mature experiments, two natures of wrought iron smooth-bore guns were adopted; these were the 100-pounder of 9in. calibre, and 150-pounder of 10·5in. calibre. They were built up on the Armstrong coil principle, but only about fifty of the former, and a dozen of the latter were made, and it soon became evident that still more potent guns were necessary, and that they could be made in the shape of wrought iron M.L. rifled guns. In fact such good results were obtained from the 64-pounder M.L. shunt gun, as well as from larger experimental guns on the same system of rifling and construction, that the O.S. committee suggested that the above two natures of smooth-bore guns should be also rifled on the shunt system.

But the shunt-rifling itself was eclipsed in 1865 by the "Woolwich" system, and as the steps which led to this result throw considerable light on the whole system of rifling, they will be briefly referred to.

By instructions first received from Lord Herbert in 1859, the O.S. committee carried on an extensive trial of cast-iron 32-pounder guns rifled for different gentlemen in accordance with their respective views as to the best way of rifling the existing store of smooth-bore cast-iron guns.

The result of this competition simply proved that cast-iron was altogether too weak and precarious a material for rifled guns.

The trial was then extended to wrought-iron guns rifled on the respective systems of Commander R.A.E. Scott, R.N., Mr. Lancaster, Mr. Jeffery, and Mr. Britten, who, with Messrs. Lynal Thomas, Hadden, Nasmyth, and Whitworth, were rivals in the cast-iron competition.

A gun rifled with French grooves and another gun with shunt grooves were also tried.

All the guns selected for competition were 7-inch muzzle-loading guns of 7 tons, built on the Armstrong coil principle, and having inner barrels of steel.

Experiments were carried on which tested these competitive guns in all the cardinal virtues of ordnance, and though the shooting qualities were alike, the O.S. committee in their final report, No. 3,730, dated 1st May, 1865, recorded their unanimous opinion in favour of the so-called French system:—

"1. Because of the simplicity of its studding on the projectiles.

"2. The simplicity of the grooving of the gun, and

"3. From a disposition to admit the advantages of an increasing, over a uniform spiral."

And further, the committee recommended "that the heavy 7-inch guns then in course of manufacture should be rifled in the same manner as the competitive so-called French gun, except that the width and depth of the grooves should be slightly decreased, and that 8-inch and 9-inch guns also should be completed with similar rifling." Fig. 1, plate 364, shows a section of the modified groove.

The Woolwich Guns.

This was the origin of those powerful pieces of ordnance known by the comprehensive term of "Woolwich guns," a binomial which may be expanded into "wrought-iron muzzle-loading guns built on Sir William Armstrong's principles improved by Mr. Anderson's method of 'hooking' the coils, and with solid-ended steel tubes toughened in oil and rifled on the French system, modified as recommended by the O.S. committee for projectiles studded according to Major Palliser's plan."

To Sir William Armstrong is undoubtedly due the merit of employing wrought-iron coils shrunk together. His main principles of gun architecture consist essentially—

Firstly, in arranging the fibre of the iron in the several parts of the gun, so as best to resist the strain to which they are respectively exposed; thus the walls or sides of a gun are composed of coils with the fibre running *round* the gun, so as to enable the gun to bear the transverse strain of the discharge without bursting; whilst the breech end is fortified against the longitudinal strain, or tendency to blow the breech off, by a solid forged breech-piece with the fibre running *along* the gun. Secondly. In shrinking the successive parts together, so that not only is cohesion throughout the mass ensured, but the tension may be so regulated that the outer coils shall contribute a fair share to the strength of the gun.

With regard to the first principle, a gun may be destroyed either by the bursting of the barrel, or by the breech being blown off. Now wrought-iron in the direction of its fibre is about twice as strong as it is in the cross direction; hence the best way to employ it to resist the transverse strain is to wrap it round and round the piece like a rope. This is the foundation of the Armstrong coil system. For a similar reason the best way to resist the longitudinal strain is to place the fibre lengthways or end on; so a breech-piece was made from a solid forging with the fibre in the required direction.

With regard to the second principle, the strength of a gun is not proportional to its thickness. The interior of a homogeneous gun bears the brunt of the discharge, while the exterior parts are scarcely affected. The exact law which regulates the amount of resistance offered to the discharge, by each lamina of the gun is not precisely known, but it is admitted that *a gun should, if possible, be so constructed that each part of its mass would do its due proportion of work at the instant of firing.*

Sir Wm. Armstrong endeavours to carry out this theory by giving, through means of shrinking, greater tension to the outer coils than to the inner ones, so that the former do a certain amount of work in compressing and energetically supporting the latter, which are thus strengthened at the expense of their exterior neighbour, and the theory is further carried out by the employment, in addition, of a stronger material (steel) for the inner barrel.

It will be observed that although our breech-loaders are commonly called "Armstrong guns," the muzzle-loaders built on the same principles have an equal right to that honourable title; but seeing that there were many modifications made by various people with regard to the rifling, &c., they have been, as already stated, styled "Woolwich guns." And this name should still be applied to the present guns, for they are a modification of the original ones, and that modification is the fruit of the Royal Gun Factories at Woolwich.

"Woolwich guns" of 7-inch, 8-inch, 9-inch, 12-inch, and 13-inch calibre—very few, however, of the higher natures—were made up to the close of 1866 on the "Armstrong" or "original" single coil system. As a type of the rest, the writer briefly described the construction of the 12-inch gun of 23½ tons.

This gun consists of a solid-ended steel barrel, a forged breech-piece, a trunnion-ring, a cascable, and nine coils—thirteen separate parts.

The steel cylinder having been bored for a barrel and toughened in oil, is turned on the exterior to suit the interior of the breech-piece, which has been built by a series of wrought-iron slabs successively welded together and then drawn out, bored, and turned. The breech-piece will not fit on the steel tube, both being cold, the difference in size being the designed shrinkage. The breech-piece must, therefore, be expanded by heat until it is sufficiently large enough to go over the end of the steel barrel, where it is allowed to cool and contract or shrink.

The screw is then cut for the cascable, and the mass taken to the turnery and turned down for the 1·*B* coil,* which is shrunk on. The mass is then turned down in succession for the 2·*B* tube, which is composed of two coils united together. This is shrunk on, and so on coil by coil, until the whole gun is built or shrunk up. The gun must still be turned on the exterior to its proper shape, rifled, proved, sighted, &c., &c., before fit for issue.

So far as strength and efficiency were concerned, these guns were nearly all that could be desired, but their expense, 100*l*. a ton in round numbers, was a serious point, and to diminish it Colonel F. A. Campbell, who succeeded Sir W. Armstrong as superintendent of the Royal Gun Factories in 1863, set practically and patiently to work. Two questions presented themselves for solution.

(1.) Could not a coarser and cheaper iron be obtained which would be sufficiently strong for the exterior of the gun?

(2.) Could not the guns be constructed in a simpler and cheaper form?

By personal visits to most of the leading ironmasters, and by a series of experiments, Colonel Campbell had already found a very superior and satisfactory iron for the inner barrels of B.L. guns, and by following up his success, he now obtained a very cheap iron sufficiently strong for the exterior of our heavy guns, whilst in the plan of construction proposed by Mr. R. S. Fraser, C.E., Royal Gun Factories, he discerned a still more gratifying solution to the second question.

Mr. Fraser's plan is an important modification of the original method, from which it differs principally in building up a gun of a few long double or triple coils instead of several short single ones and a forged breech-piece.

For example, in addition to the steel barrel and cascable, a "Fraser" gun of the pattern most generally followed has only two separate parts, viz., the breech coil and *B* tube (or as they are sometimes familiarly called "the jacket and trowsers") whereas the 9-inch gun of original construction has a forged breech-piece, a *B* tube, a trunnion ring and seven coils—ten distinct parts—which are shrunk on separately. (See figs. 2 and 3, Plate 364.)

The formation of a double or triple coil is a simple forged operation, but great expense is saved by its means, as there is so much less surface to be bored and turned, for each coil having to be made as smooth as glass and at the same time true to gauge (to a thousandth of an inch) it follows that it must be cheaper to have a few thick ones in lieu of many thin ones. For the same reason there is also less waste of material, for although the turnings are afterwards worked up into bars, iron in its scrap state is only worth one-third of its forged value.

Moreover, time and labour are also saved in having fewer pieces to move from workshop to workshop; for instance, in the case of a gun of original construction, when a coil was shrunk on, the mass had to be moved from the shrinking pit to the turning lathe, and turned down for the next coil, and so on, coil by coil, until the gun was built; but in the new construction, only two or three separate shrinkings are required; and it is computed that where 50 tons were moved in the former case, only seven are moved in the latter.

From these circumstances, combined with the employment of cheaper iron, a "Fraser" gun can be made at two-thirds of the cost of a gun of the same nature as originally manufactured.

But it will be naturally asked, is this cheap construction as strong as the old one?

With respect to theory it may be urged in its favour, in the first place, that a forged breech-piece (which is a comparatively expensive article, and liable moreover to fly into fragments should the gun burst) is not required with a solid-ended steel barrel and long thick coils, although it is absolutely necessary with several short coils to compensate for the longitudinal weakness of their several joints. The whole of the wrought iron therefore can be *coiled* round the barrel and thus give extra transverse strength. Again, the trunnion ring, which was merely shrunk on in the original construction, is *welded* on to the breech-coil in the Fraser construction, so there is no fear of the slipping which sometimes took place in the early Armstrong guns.

With regard to the second Armstrong principle already stated, although a series of thin coils help us to distribute the induced strain on a gun by shrinking on each coil separately, the method is open to the serious objection that it is practically difficult to calculate the respective proportionate amount of tension, and consequently the greater the number of pieces in a gun, the more likely some weakness will exist in the mass owing to the undue strain on some of the parts; for instance, a 13-inch gun of original construction (Experimental No. 300) split some of its outer coils while the interior ones remained

* The various coils are lettered as a ready mode of description.

uninjured, thus clearly proving that there was too great strain on the former. Shrinking on the coils successively was adopted by Sir William Armstrong as a conveuient mode of adhesion and not on the distribution theory, which was subsequeutly enunciated. In the formatiou of a triple coil it is generally a manufacturing necessity to have the first coil cold before the secoud bar is wound on, but the third bar is wouud on whilc the second coil is hot; the second and third layers therefore cool aud coutract simultaneously, aud are kept in a state of tension by the first, which they compress to a certaiu degree. So here also the theory may be carried out, for assumiug that iron expands irrespective of its density, the three layers could not recover their natural condition on subsequent heatings.

But "one fact is worth a cart-load of argument;" and one grand decisive fact bearing on this question was the favourable result of the trials for comparative endurance which 64-pounder and 9-inch specimen guns on the cheap construction underwent, and in virtue of which it superseded the original single coil system of Sir William Armstrong at the close of 1866.

Again, when two years afterwards a "Fraser" 9-inch gun burst at proof, although hundreds of the same sort had stood the proof without wincing, although it was evident that thc gun which failed had a defective steel barrel, nevertheless, to make assurance doubly sure, as well as to ascertain which of the two constructions proposed by Mr. Fraser was the stronger, two 9-inch guus were subjected to a very severe test with most satisfactory results.

The 9-inch gun No. 1 consisted of five parts, viz., a thin steel barrel, a *B* tube, two breech coils, and a cascable. It had previously fired 500 rounds with full charges (30 lbs.) and 214 with battering charges (43 lbs.), the vent being at the rear—a fact which causes less strain on the gun than when the vent is further forward. The old vent having been plugged, and the gun vented on the underside in the service position, *i.e.*, about 9½ inches forward, it was subjected to a crucial test of 500 rounds with battering charges at the rate of 50 rounds a day—an ordeal which it accomplished most triumphantly 11th March, 1869. So that this gun fired altogether 1,114 rounds, of which 714 were with battering charges—a great increase on the number of rounds laid down for the service of a 9-inch gun.

No. 2, a new 9-inch gun, of the service pattern, that is, reinforced with a triple coil, like the gun that burst, was then subjected to the same test as No. 1 had uudergone, in order to ascertain which of the two modifications of the new construction was the stronger. It fired 400 rounds with full, and 207 with battering charges, with the vent in rear; it was then turned over, vented in the service position, and the second part of the programme, namely 500 rounds with battering charges, was commenced. At the 100th round, the impressions showed a faint crack in the steel tube at the crown of the bore. This increased regularly to the 401st round—that is, the 1008th round of all—when the gas escape indicated that the breech end of the tube was split right through. After this the gun fired 41 rounds, and then at length, at the 1049th round, the *A* and *B* tubes were bodily forced about au inch forward. This closed the vent, and consequently put an end to the trial.

The result was deemed most satisfactory, not only because the steel tube failed so gradually, but because the great strength of the outer fabric—the poiut at issue—was proved beyond all doubt by the gun actually firing 41 rounds after the tube was split through, and yet remaining sound exteriorly.

Both guns behaved so exceedingly well under trial, that the authorities were left in the pleasant dilemma of not knowing which pattern to choose, No. I, with a steel tube 2 inches thick, and reinforced with two double coils, surviving the trying ordeal. No. 2, with a steel tube 3 inches thick, and reinforced with one massive triple coil, did not, it is true, complete the test, but it refused to yield, although its tube was split.

With respect to the precise pattern for future construction, it would, perhaps, have been the safest course to have continued firing No. 1 gun, and then, if it did not blow its breech off (its tube being so thin), or burst explosively without giving ample warning, to have adopted it as the pattern of all the heavier natures. The authorities, however, have decided on constructing 7-inch and 8-inch guns as before, on the No. 2 type, but to make 9-inch guns and upwards, on the No. 1 type.

It will be observed that the adoption of the present coustruction is not due to the caprice of an individual authority, or to the Parliamentary influence of an inventor, but that it is the ripe fruit of ten years of the most scientific aud exhaustive experiments which the artillery world has ever seen.

Present State of the Question.

The question then stands thus:—Up to April, 1867, all our heavy guns were made ou the original construction, like the 9in. gun, Fig. 2, and from that date up to the present nearly all have been made like the 9-in. gun No. 1, or fig. 3—*i.e.*, consisting only of four parts, viz., stecl tube, cascable, *B* tube, and breech coil, and 7-in. and 8-in. guns will still be made in thc same way. Of all these the 9-in. gun is thc most important; it is very powerful for its weight, and has becn made in considerable numbers; it is therefore taken as a type of the most common form of the prcsent construction, and its manufacture will now be described in detail.

The alteration in future manufacture for 9-in. guns simply consists in having a thinner steel tube aud two coils on the breech, instead of one triple one; or perhaps the difference in construction will be more readily remembered by using thc familiar illustration, and sayiug that in the former instance the stecl tube is enveloped in "jacket and trousers," whilst in the latter it is thinner, and has "jackct, waistcoat, and trousers." The higher natures are made in the same way, but have a "belt" in addition.

Details of the Manufacture of a 9-in. Gun, Fig. 3.

The gun consists of—

An inner barrel or tube of steel.
A *B* tube.
A breech coil.
A cascable.

The Inner Barrel.

The inner barrel, which when in the gun weighs only 36 cwt., is madc from a solid forged cylinder of cast steel, weighing 67 cwt., which is supplied to the Royal Gun Factories by the contractors, Messrs. Firth, of Sheffield. Casting is necessary, not only for the purpose of obtaining a sufficiently large block of stcel, but also for making the block homogeneous and uniform in density. Forging, or drawing out the cast block, imparts to it the desirable properties of great solidity and density.

The block is sent to the Royal Gun Factories, where it is subjected to the following tests and treatment:—

A slice is cut off from the brecch end and divided in pieces for testing. Some of these arc flat bars, 4in. long and ⅜ by 3-8ths in section, and others are of the shape usually tested in the machine for tensile strength aud elasticity. Three of the former are marked respectively *S*, *L*, aud *H*. One end of the *S* or soft (*i.e.*, untempered) piece is gripped in a vice, whilst the other end is hammcred down towards it, to ascertain that the steel, by bearing this bending without crackiug, is naturally of the mild quality required. The *L* and *H* piecs are raised to a low red and high heat respectively, immersed in oil, and, when cold, treated in a similar manner.

Whichever of these pieces bears thc hammering best, determines the heat at which the whole tube is to be toughened. Should neither piece answer, others at intermediate temperatures are tried, and if all fail, thc block is returned to the contractors; but some specimen having succeeded, as is generally the case, two of the remaining pieces—one in its soft state, and the other toughened at the ascertained temperature—are tested for tensile strength and elasticity.

A steel ingot or block which stands all the foregoing tests is rough turned. In this operation a lip or collar is formed at the muzzle, to facilitate the lifting of the tube in and out of the furnace and oil bath. The fine turning is not done until the *B* tube and breech coil are gauged and ready to be shrunk on.

The block is next bored roughly from the solid, 8¼in. of diameter being taken out by one cut in segmental chips 1-8th of an inch thick.

The tube thus formed is now ready for toughening in oil. This consists in heating the roughly bored tube (from four to five hours) to the approved temperature in a vertical furnace, and then plunging it bodily into an adjacent bath of rape oil, in which it is allowed to cool and soak till next day, generally 12 hours or more.

The effect of toughening steel in oil is to increase the elasticity and tensile strength; the process, however, is not without some slight disadvantages—it not only warps the steel a little, but frequently causes the surface to crack. The barrel must therefore be slightly turned and bored to make it straight inside and outside, as well as to remove any flaws that may have been generated. By these means the cracks are generally removed, but several tubes have been rejected in consequence of flaws still appearing to penetrate to a dangerous depth, and lest there should be any not visible to the eye, the steel barrel is subjected to the water test of 8,000lbs. per square inch, and if no flaw is detected by the formation of moisture on the exterior, the tube is considered safe and sound. The barrel is left in this state until the *B* tube is ready to be shrunk over it.

The *B* Tube.

The *B* tube is composed of two single and slightly taper coils united together. The first coil is formed of two bars joined together—one 16ft. long and 5½in. × 4¾in. × 4⅜in. in section, the other 33ft. by 5in. × 4½in. × 4in. The second coil is also composed of two bars—one 18ft. by 4½in. × 4½in. × 4in., and the other 31ft. by 4in. × 4in. × 3½in.

The two coils, being made and welded in the usual way, are faced and reciprocally recessed to the depth of about 1in., and then united together endways by expanding the faucet of one coil by heat, and allowing it to shrink round the spigot of the other. This sticks the two coils sufficiently tight together to admit of the tube thus formed being placed upright in a furnace, whence, when it arrives at a white or welding heat, it is removed to a steam hammer, and receives on its end six or seven pressing blows which weld the joint completely. The weight of the tube in this rough state is about 55½ cwt., but when finished, as it is on the gun, it only weighs 31 cwt.

The *B* tube is next rough turned, in which process a rim is formed near the muzzle for the convenience of lifting the tube in "shrinking." After this, the tube is next "rough" and "fine bored" in the same horizontal machine.

The interior of the *B* tube having thus been brought to the degree of smoothness requisite for the close contact with the steel barrel, is gauged every 12in. down the bore, and also at the shoulder. To the measurements thus obtained, the calculated amount of shrinkage is added; a plan is made out according to which the exterior of the *A* tube (or rather that portion of it on which the *B* tube is to go) must be turned down, in order that it shall be exactly larger than the bore of the tube by the required amount of shrinkage at the respective parts.

The plan is made on a slip of paper, and together with a corresponding series of accurately measured horseshoe gauges, is furnished to the turner, who turns down the muzzle end of the *A* tube accordingly.

The reason an *inner* tube is turned to suit an exterior one, instead of the latter being bored to suit the former is, that it is much easier to turn than to bore to very exact dimensions, on account of the great command which the operator has over the turning lathe, and the facility he has of testing his work by gauges, and correcting it by emery powder and oil.

The Breech Coil or Jacket.

The breech coil or jacket is composed of a triple coil, a *C* double coil, and a trunnion ring, made and welded together as follows:—

The Triple Coil is made of three bars all of the same section, viz.—4½in. × 4½in. × 4in., but differing of course in length, the first or innermost one being 78ft., the second 118ft., and the third 158ft. in length, the middle one being coiled in the reverse direction, so as to break joints. In order to weld its folds, it is placed in a furnace for about ten hours, at the end of which time it is at a welding heat, whereupon it is rapidly transferred to a powerful hammer, and receives a few smart blows on its upper end, which close the folds longitudinally. A maudril somewhat larger in diameter being then forced down it, it is turned on its side and well hammered all round to make it dense. It is replaced in the furnace for about six hours, and the same process repeated at the breech end, but with a smaller mandril.

When cold, the ends are faced and the outer coil is turned down at the muzzle end to form a shoulder 14in. long for the reception of the trunnion ring.

The C coil is made of bars of the same section as those used for the triple coil. The inner bar is 46 feet in length, and the outer one 69 feet. This double coil being welded, has a shoulder formed on the lower end about 9 inches long and ¾ inch deep, so that it may overlap the trunnion in the welding.

The trunnion ring is made like all wrought-iron trunnion rings—namely, of slabs of iron consecutively welded together on the flattened end of a porter bar, and gradually formed into a ring by means of, first, a small iron wedge, which is driven through the centre and punches an oval hole, and then by a series of taper mandrils increasing in size, which make the hole sufficiently large and round. The trunnion ring has to be heated for each punching, and the occasion is used to hammer the trunnions into shape, one of which is in continuation of the porter bar. Eventually the ring is cut off from the bar by means of strong blunt hatchets of steel hammered through it. The trunnion ring is next roughly bored out.

All the three parts (breech coil, *C* coil, and trunnion ring) being thus prepared, the trunnion ring is heated to redness, lifted by a crane, and dropped on to the shoulder of the triple coil, which is placed upright on its breech end for the purpose.

While the trunnion ring is still hot, the *C* coil is dropped down upon the front of the triple coil, through the upper portion of the trunnion ring which was left projecting. The trunnion ring thus forms a band over the joint, and in cooling contracts round the two coils, and grips them sufficiently tight to allow of the whole mass being placed bodily in a furnace, where it is raised to a welding heat in about thirteen hours (see diagram, breech coil, trunnion ring, and *C* coil ready for welding, Plate 364).

The glowing mass is then quickly placed on its breech end under the most powerful hammer in the department. Six or seven blows on the top suffice to amalgamate the three parts together; but to make the welding more perfect on the interior, as well as to obviate any bulging inside, a cast iron mandril somewhat larger than the bore is forced down to within 20in. of the breech end, a series of short iron plugs being used to drive it down. The mass is then reversed, and the mandril is driven out with the same plugs, which have fallen out in the tilting over.

The rough jacket thus made weighs over 16 tons, but this weight is reduced to 9 tons by the turning, rough and fine boring, &c., which are necessary to bring it to the proper size and shape.

The body is turned in a very powerful lathe, weighing, with its foundation, 100 tons, to the required shape. The operation takes sixty hours.

It being impracticable to turn down the trunnion belt in a lathe, it is slotted smoothly down by a self-acting vertical machine with a double motion, one of which moves the jacket round for a fresh cut at every stroke of the tool which the other works up and down accordingly.

The trunnions themselves have yet to be turned down to shape; so the jacket has to be moved for the purpose to another machine—a break lathe—in which it is made to revolve on the axis of the trunnions, while the sliding cutters act on their surface.

The jacket is next rough and fine bored in a machine like that used for the *B* tube, but stronger, and the front of the *C* coil is recessed on the inside to a depth of 9in., and broad enough to overlap the *B* tube.

Finally, the female thread for a cascable is cut by a machine in which the jacket revolves horizontally, while the cutter is fed forward by a copying screw—one pitch for every revolution of the jacket.

Building up the Gun, or shrinking the Parts together.

The steel barrel and *B* tube being prepared for one another as described, are shrunk together in this manner:—The *B* tube is placed on a grating, and heated for about two hours by a wood fire, for which the tube itself forms a flue, until it is sufficiently expanded to drop easily over the muzzle end of the steel barrel, which is placed upright in a pit ready to receive it. The *B* tube is then raised, and the ashes, &c., being brushed from the interior, is dropped over the steel barrel by means of a travelling crane overhead. During the process of shrinking, a stream of cold water is poured into the steel barrel, to keep it as cool as possible, the water being supplied and withdrawn by a pipe and syphon at the muzzle. A ring of gas is placed at the muzzle or thin end of the *B* tube, to prevent its cooling prematurely, whilst jets of cold water play on the other end, and are gradually raised to the muzzle, for the purpose of cooling the whole tube consecutively from the breech end, which it is desirable should grip first, to ensure a tight fit at the shoulder. Moreover, were both ends allowed to contract simultaneously, the intermediate part of the tube would be drawn out to a state of longitudinal tension, and weakened accordingly.

The *A* and *B* tubes shrunk up (see diagram), are placed in a lathe, and while one cutter fine-turns the *B* tube to its proper shape and dimension, another cutter fine-turns the breech end of the *A* tube according to the plan of the breech coil, which has been made out on a principle already explained.

The half-formed gun, composed of *A* and *B* tubes shrunk up, being next placed standing on its muzzle in the shrinking pit, the jacket is heated for about ten hours, and shrunk on in the same manner as the *B* tube; it is, however (being nearly of the same thickness throughout) allowed to cool naturally, and the cold water has to be forced up, fountain fashion, into the bore of the gun by a jet round which the muzzle rests.

The process of building up a 9-inch gun is very similar. There are, however, three shrinkings instead of only two—viz., the coiled breech-piece on a breech-end, the *B* tube on the muzzle end of the barrel, and then the outer breech coil over the inner one.

Processes after the Gun is built up and before proof.

These are:—

(1.) Screwing in the cascable.
(2.) Engraving the Royal cypher.
(3.) Fine-boring.
(4.) Second rough-cutting of chamber.
(5.) Finished boring.
(6.) Broaching of bore, and finishing of chamber.
(7.) Lapping.
(8.) Rifling.
(9.) Temporary venting.

(1.) *The cascable* is made of the best scrap iron. It is first forged into a simple cylinder; it is then turned, and a bevel thread cut on it. The button is turned on it, and a hole (which is afterwards enlarged into the loop), is drilled through one end, for the purpose of screwing it into the gun. The operation of screwing in the cascable requires great care, for the front of it must bear evenly against the end of the steel barrel, and in order that this may be the case, the end of the tube is smeared with red lead and the cascable screwed in tentatively, then unscrewed again, and filed down on the prominent parts, which are indicated by the absence of the red lead. This is repeated several times, until the equal distribution of the lead on the front shows that it bears evenly against the steel barrel.

At this stage, one round of thread is turned off the end of the cascable, so that there may be an annular space there, which in connection with a channel now cut along the cascable and across the thread, will form a gas escape, or tell-tale hole, in case the steel barrel should split at the end. The channel is about three-eighths inch broad, and extends one-tenth inch below the thread. In all guns made before the 1st September, 1869, the channel comes out directly under the loop; but in guns made since that date, it will be found at the right side of the loop, where it may be more easily noticed. The channel ought to be kept clear, and should the barrel be split at the end, some gas may be seen issuing from the hole; it is therefore advisable to keep an eye on this hole, and to cease firing, should it give warning.

When at length the cascable fits properly, it is screwed in, and to prevent its moving, a hole 2¼in. long and ¾in. in diameter is drilled and tapped through the male and female threads in a slanting direction on the left side, and a plug is screwed in.

(2.) While the cascable is being prepared, Her Majesty's monogram is engraved in front of the vent, the outline being marked on the gun by means of a perforated brass plate, rubbed over with charcoal.

(3.) The gun is next removed to the boring mill, where it is fine-bored to 8·9in.

(4.) The chamber is next roughly bored out with the same boring head as before.

(5.) The finished-boring to 8·997in. is then performed.

The fine-boring and the finished-boring are effected with the boring-head used in the second rough boring, and together occupy twenty-six hours.

(6.) In each boring the cutters wear a little during the operation, so that the bore becomes slightly taper towards the breech. This is of no consequence in an outer tube, as the exterior of the inner one can be turned accordingly, but the bore of the gun must be cylindrical, so broaching is employed—that is, boring the barrel by means of a cylindro-conoidal head, fitted with four long cutters at right angles to one another, and slightly tapering. The cutters are edged on the front as well as on the side, as the chamber is also finished off at this time, and for this latter purpose there is also a peculiar centre cutter for the very end of the bore.

(7.) Still, however, the bore is not yet truly cylindrical, and "lapping" is resorted to. In this no cutter is used, but a wooden head, covered with lead and smeared over with emery powder and oil, is worked up and down at those portions of the bore which are indicated by the gauges as imperfect.

(8.) The 7in. M.L. guns are rifled with a uniform spiral—*i.e.* with grooves having the same amount of twist at every point of the bore; and all the higher natures with a uniformly increasing spiral—*i.e.* uniformly increasing from the breech to the muzzle. The advantage of an increasing spiral is, that the inclination of the grooves, being little or nothing at the breech, the projectile's initial motion is not checked by any resistance offered to the studs. The projectile therefore moves quickly from its seat, and relieves the breech a good deal from the strain of the discharge.

The groove is of the "Woolwich" shape, 1·5in. wide and 0·18in. deep, with concave edges. It is the same width for all natures, but it is a little deeper for the 10in. and 12in. guns. The number of course varies with the calibre, 7in. guns having three, 8in. four, 9in. six, 10in. seven, and 12in. nine.

As a rule, about two calibres in length is left plain or unrifled for a powder chamber. The exact proportion is not fixed. The unrifled part however, should be no shorter than actually necessary to prevent a detrimental air space between the smallest charge used and the base of the projectile, as the grooving tends to weaken the barrel very much, and the seat of the charge should be the strongest part of the gun.

(9). Previous to the 23rd January, 1868, rifled M.L. guns were left altogether unvented until after proof, at which they were fired by means of electric wires passed in at the muzzle. Since that date, all guns are drilled and tapped before proof, and fired through a removable steel vent, which is unscrewed after proof and replaced by the permanent vent; the object of this is to prevent the proper vent being strained by the large proof charge.

Proof.

Before a gun is proved, gutta-percha impressions are taken of the whole length of the bore in the four quarters. The gun is then proved with two rounds—the projectile being equal in weight to the service one, but flat-headed, for 7in. guns and upwards, in order that it may penetrate as little as possible into the butt, and the charge being 1¼th the weight of the battering or highest charge used in service. The gun is fired in the open by means of an Abel's electric tube, connected with a magneto-electric battery in a bomb-proof shed.

With the early rifled guns much larger charges were used at proof, and then service charges and a double-weighted shot were used for some time; but this was found to strain the gun too much, and the Ordnance Select Committee having thoroughly investigated the matter, and having obtained the particulars of proof of guns in France, Belgium, Holland, Austria, Spain, Saxony, Denmark, America, Wurtemberg, Bavaria, and Sweden, came to the conclusion that the proof should be based on the highest charge which the gun will have to bear on service, and recommended the present proportionate charge for rifled M.L. guns, which was approved 13th July, 1864.

After proof, water is force-pumped into the bore, with the pressure of 120lbs. to the square inch. This was instituted for guns with wrought-iron barrels to ascertain that the breech was perfectly closed, and is still continued in the case of solid-ended steel barrels, to make sure that the end has not been split in proof. After this the gun is cleaned, and gutta-percha impressions of the bore being taken as before, the two sets of impressions are compared, to ascertain that no flaw of a serious character has been developed by proof. If any defect appears of which there is even the slightest doubt, the gun is subjected to five more rounds with service charges, and if after that the flaw does not appear to have increased, the gun is passed.

PROCESSES AFTER PROOF AND BEFORE ISSUE.

(1.) Lapping.
(2.) Obtaining preponderance and weight.
(3.) Lining.
(4.) Sighting,
(5.) Venting.
(6.) Marking and the "marks" denoting pattern.
(7.) Fixing on elevating plates and small fittings, sloping sides of cascable, and scoring breech.
(8.) Painting and lacquering, and final inspection.

All the above processes, except the last, are performed in the one workshop (the sighting room), and generally, but not necessarily, in the exact order given.

(1.) Every gun is *lapped* after proof, for the purpose of removing any little burrs which may be thrown up on the edges of the grooves by the impetuous proof rounds.

(2.) The meaning of the term "preponderance" as applied to modern guns, is the pressure which the breech portion of the gun, where horizontal, exerts on the elevating arrangement.

The preponderance of heavy guns should be as small as possible, so as not to interfere with the easy action of the elevating arrangement. 5 cwt. was assigned for 9-inch guns, and between 5 and 6 cwt. for the heavier guns; but by a recent order, 14th April, 1869, all sea-service guns of 18 tons and upwards are to have no preponderance, and as this is practically impossible, it is further stated that anything under 3 cwt. will be considered as none.

The actual *weight* of each gun is taken by means of a strong steel-yard, to the short arm of which the gun is slung by the trunnions.

(4.) M. L. guns are *sighted* like B.L. guns on both sides, and with the same kind of tangent sight; but M.L. guns have in addition short centre, hind, and fore-sights. They have therefore three pairs of sight attached to the gun, and besides these there is a wood scale for use on board ship.

(5.) *The vent* in rifled M.L. guns does not enter near the end of the bore as in S.B. guns but at a point two-fifths the length of the service cartridge from the end, for it has been proved by experiment that by igniting the cartridge at this point, the maximum initial velocity is obtained.

Up to 1st November, 1868 the vent bushes were the ordinary copper cone vents, let in perpendicularly, but at that date a new kind of vent (proposed by Major Palliser) was inserted in the 10-inch gun. This vent consisted of a steel bush, lined with copper, screwed in from the exterior against a platinum tip screwed up from the interior, the tip having a flange or button-shaped head projecting into the bore to close the joint; and instead of entering the bore vertically, it was fixed upon the side* of the gun at an angle of 45 to the vertical axis, in order that it might be more easily served (see List of Changes 1st December, 1868). It was subsequently decided (25 November, 1868), that all wrought-iron guns of seven inch calibre and upwards should have similar vents, but let in vertically as before, except in the case of guns of 10-inch calibre and upwards, whose size would render the vertical position awkward.

This was acted on for a short time, but the vents not proving satisfactory, the employment of the platinum tip was suspended, and steel vents lined with copper were used; but as these too did not answer expectations, all the big guns are now vented with copper specially hardened, the letter *H* being stamped on the top to indicate the fact.

The matter, however, is not yet settled; platinum-tipped vents, without the flange, are under trial. The more powerful the gun, the greater is the wear and tear on the vent. Simple copper vents are most satisfactory for guns up to a certain size, and in spite of the softness of this metal, many think it will answer for very large guns quite as well as a more costly material.

This difficulty about vents is only one of the many which have to be overcome before we can obtain heavy guns perfect in every respect.

(6.) In addition to the *marks* made in lining, and the Royal cypher before mentioned, the broad arrow and actual weight are stamped behind the vent, and two parallel lines are cut across the vent field to indicate the unrifled space. The material of the inner barrel (for example *Firth's steel*) is stamped on the face of the muzzle, as is also the number of the steel barrel as entered in the registry of manufacture.

On the left trunnion are the initials R.G.F., the register number of the gun, the numeral signifying its pattern, and the year of proof. The register number is that by which the gun is registered in the department records; it indicates also the number of that nature manufactured. With respect to the numeral, the word "pattern" was superseded by "mark," and the construction of guns has been designated accordingly since 20th April, 1868.

(7.) *The extra fittings* or appurtenances of M.L. guns are very few and simple when compared with those for B.L. ordnance. They are limited to gun-metal elevating plates for guns for both services, guide-plates, and friction tube pins for sea service, and muzzle studs and shot bearers for land service.

(8.) The exterior of the gun being well cleaned, receives one coat of "Pulford's magnetic paint," which is now used for all iron guns instead of anti-corrosion, to which it is superior in point of cheapness and durability The bore receives one coat of the usual *lacquer*.

Finally. The gun and all its fittings having been inspected, and found in exact accordance with the sealed pattern, is issued for service.

* The vent is on the right side of the gun if intended for broadside purposes, but if for a turret gun, the vent is placed on the right or left hand side as convenience demands.

LONDON CHATHAM AND DOVER RAILWAY.

FIRST AWARD OF ARBITRATORS.

The Arbitrators appointed under the London, Chatham and Dover Arbitrations Act, the Marquis of Salisbury and Lord Cairns, have issued their first award which as it includes all the most important items, will probably be interesting to our readers as a commercial engineering precedent. Under the head of "Consolidation of Undertaking" it provides:—As from and after the 30th day of June, 1870, the separate undertakings and sections of the company and of their undertaking known as the General Undertaking (including the steam boats), the Metropolitan Extensions, the Victoria Station Improvements, the City lines, and the eastern section, with the separate capitals raised in respect thereof, shall be and are hereby consolidated into one undertaking with one capital.

Superfluous Lands.—The company shall, from time to time, with the best dispatch, and within three years from the date of this award, sell and convert into money all their superfluous Lands. If this is not done in three years, or in such extended time as the Board of Trade may allow, the power of sale may be vested in three or more persons, to be selected by the Board of Trade direct. Elegits.—The London, Brighton, and South Coast Railway Company shall not recieve any rents and profits of superfluous lands extended under the writ of elegit issued on the judgment obtained by them against the company.

Creation of Debenture and Ordinary Stock.—All powers immediately before the date of this award vested in the company of raising any further share or loan capital, or of creating or issuing any debenture stock, debentures, mortgages, shares, or stock are annulled.

The company to create stock as follows:—

1. Debenture stock to the amount of 5,000,000*l.* to bear interest at 4½ per centum per annum, and to be called London, Chatham, and Dover

Arbitration Debenture Stock (in this award referred to as Arbitration Debenture Stock):

2 Preference Stock to the amount of 4,394,289*l* to bear a preferential dividend of 4½ per centum per annum and to be called London, Chatham, and Dover Arbitration Preference Stock (in this Award referred to as Arbitration Preference Stock):

3 Ordinary stock to the amount of 7,743.405*l*. to rank after arbitration preference stock, and to be called London, Chatham, and Dover Arbitration Ordinary Stock (in this Award referred to as Arbitration Ordinary Stock).

Redemption of A Debenture Stock.—The company to redeem at par the stock 30,250*l*., and to pay interest thereon to 30th June, 1870. Payments in Full.—The company to pay to the bodies and persons named in Schedule C, "payments in full" to this Award or their representatives as regards such of those bodies and persons as are named in Part III. of that Shedule, as and when payments to them become due and payable, the several sums therein mentioned, and the same shall be accepted by those several bodies and persons in full satisfaction and discharge.

Discharge of Liabilities—Schedules D and K.—The company are to discharge these by appropriating to the holders of the debentures and stock (other than B debenture Stock), Arbitration Debenture Stock to their respective amounts. The liabiiites described in Shedule E of the Award to be discharged by issuing to the holders debenture stock, arbitration preference stock, and arbitration ordinary stock to their respective amounts. The liability in respect of the capital amount of the contribution made by tho Great Northern Railway Company towards the City lines capital to be discharged by an issue of arbitration preference stock, and arbitration ordinary stock to the amounts stated in Schedule F of the Award. The liabilities described in Schedule H of the Award to be discharged by issuing to the holders of the debentures therein described arbitration prefereene stocks to their respective amounts. The company to pay to the persons named in Schedule K of the Award the sums set opposite their names, and shall on demand issue to them arbitration stock to the amounts set opposite their names. The payment of money and appropriation of arbitration stock to be in full discharge of the claim, the company to cancel the following portions of their existing share capital:—The sum of 154,000*l*. Victoria Station Improvement Stock, being the nominal amount of that stock above the sum of 366,000*l*. mentioned in Schedule D—"preferential liabilities"—to this Award; the whole of the City lines share capital except the shares described in the list refered to in Schedule L—"City lines share capital"—to this Award; the sum of 700*l*. Dover Five per Cent. First Preference Stock being in the hands of the company; and the shares in the eastern section share capital. In substitution for existing preference share capital the company to appropriate to the several holders thereof arbitration preference stock to the aggregate amount of the existing preference stock therein stated. The company to appropiate to the several holders for the time being of the existing preference stock and shares described in Parts II. and III. of the Schedule M arbitration preference stock and arbitration ordinary stock, to their respective aggregate amounts, and after 30th June, 1870 all claims to dividends on the existing preference shares or stock described in the schedule referred to shall cease. The interim management of the company to be discharged by the board under the Arrangement Act of 1867. After 30th June 1870, the net revenue of the company to be applied to payment of interest on arbitration debenture stock payment of the preferential dividend on arbitration preference stock, and payment of dividend on arbitration ordinary stock. Payments of money and issue of arbitration stock to be in full satisfaction of claims. The suits and proceedings in the Court of Chancery referred to in Part I., Schedule P., shall be absolutely stayed, but only as against the company where so expressed in that schedule. Nothing in the award to affect the right of the company or of any person or body to proceed in bankruptcy againt Sir Samuel Morton Peto, Edward Ladd Betts, and Thomas Russell Crampton, or any or either of them or to proceed in bankruptcy or otherwise against the assignees of them or to recover or receive any dividend paid in bankruptcy in respect of any claim which as against the company is provided for by this Award. The company with the best dispatch to complete and open for traffic the eastern section from Nunhead to Blackheath-hill (Greenwich) expending a sum not to exceed 25,000*l*. Crystal Palace, Kent Coast, and Sevenoaks Companies.—As from the 30th day of June, 1870, the Crystal Palace, Kent Coast and Sevenoaks Companies (in this award referred to as the three companies) shall each be charged with the actual cost of the maintenance and working of their railway taken or ascertained as in this award provided. The traffic receipts accruing from traffic passing to and from the railways of the three companies respectively from and to any portion of the system of the company shall be divided between the three companies respectively and the company according to mileage. The actual cost of maintenance and working as aforesaid shall be deducted from the aggregate amount of the traffic receipts aforesaid to be allotted to the three companies respectively, and the balance shall be paid to them respectively by the company at the times and in the manner in this Award provided. Each of the three companies shall be entitled to retain or have for their own use all net receipts from their undertaking other than traffic receipts. The differences between any of the three companies and the company to be referred to a competent and impartial person, to be appointed by the President of the Institute of Civil Engineers.

TRIAL TRIP OF H.M.S. "IRON DUKE."

The new ironclad *Iron Duke* left Plymouth Sound on the 17th ult. for the official trial of her machinery. She is 3,787 tons burden, and her armament consists of ten 12-inch Fraser guns, in the central batteries on the upper and main decks (worked by Captain Scott's gear), besides four 64-pounders. Her plating is six inches to the water-line and eight inches above. The *Iron Duke* was built at Pembroke, and her engines, which are by Messrs. Ravenhill and Hodgson, of Limehouse, are horizontal direct acting, of 800 nominal horse-power, and are calculated to be worked up to 4,800, or six times the nominal horse-power. She is fitted with surface condensers and super-heating apparatus. In the preliminary trial on the 15th ult. the mean number of revolutions was 81 per minute, and at the official trial they were the same, giving a mean speed at full power of 13·855 knots per hour, and at half-speed a mean of 11·387 knots; the revolutions at half-power being 66 port and 63½ starboard respectively; the surface-condensers gave a mean vacuum of 26. Experiments were also made in turning circles at full speed with both screws. With the helm hard-a-starboard and angle of rudder 29 degrees, the times were—for the first half-circle, 2min. 35secs.; whole circle, 4min. 48sec.; diameter of circle, 505 yards. With the helm hard-a-port and anglo of rudder 28 degrees, the times were—for the half-circle, 2min. 17sec.; whole circle, 4min. 29sec.; diameter of circle, 505 yards. Trials were then made in circle-turning from rest. With helm hard-a-starboard, port engine full speed astern and starboard engine full speed ahead, the time occupied in making the half-circle was 4min. 28sec.; whole circle, 8min. 26sec. The helm was then put hard-a-port, with starboard engine full speed astern and port engine full speed ahead, and the time taken in making the half was 4min. 29sec. and whole circle 8min. 12sec. The trials from rest were continued with helm amidships, the starboard engine full speed ahead and the port engine stopped, and then the half circle was made in 5min. 43sec., and the whole 10min. 16sec.; diameter of circle 754 yards. The helm was still kept amidships, the port engine put at full steam ahead and the starboard engine stopped, when the half circle was made in 5min. 20sec., and the whole circle in 8min. 48sec., diameter of circle 754 yards. In the next evolution the helm was put hard-a-starboard, the starboard engine at full speed ahead and the port engine stopped, and then the half-circle was made in 3min. 41sec. and the whole circle in 6min. 44sec.; diameter of circle, 420 yards. With the helm hard-a-port and port engine full speed ahead, with the starboard engine stopped, the time taken in making the half-circle was 3min. 38sec., whole circle, 6min. 36sec.; diameter of circle, 378 yards. The engines were stopped in ten seconds, and were started astern in 14sec. after the signal was given. The engines going astern were started ahead in 20sec. from the time that the telegraph was moved. The best navigation coal was used during the trial.

THOMSON'S ROAD LOCOMOTIVE.

A Parliamentary paper just issued will be read with interest as showing that the time approaches when the advantages of Steam on Common Roads is likely to be appreciated.

Mr. Anderson, the superintendent of machinery, says he has "come to the conclusion that the question of steam traction on common roads is now completely solved;" that the application of the india-rubber tire is a perfect success; that it opens up an entirely new field, and that he looks upon this application as a discovery rather than an invention. The wheel and its tire may be described as consisting of a broad iron tire with narrow flanges, upon which is placed a ring of soft vulcanised india-rubber; this ring is about twelve inches in width and five inches in thickness, which thus surrounds the iron tire, and is kept in its place by the flanges; then over the india-rubber there is placed an endless chain of steel plates, which is the portion of the wheel that comes into actual contact with the rough road, the reticulated chain being connected by a sort of vertebra at each side of the wheel. Tho india-rubber tire and this ring of steel plates have no rigid connection, but are at perfect liberty to move round as they please with consulting each other or even without the concurrence of the inner ring of the wheel which they both enclose. Mr. Anderson states that the reason why this wheel is so efficient is because the soft india-rubber allows it to flatten upon the road, whether rough or smooth. Tho wheel, being a circle, if it is a rigid structure, presents but a small surface, but this wheel confirms to every irregularity for a space of nearly 2ft. by the weight of the engine causing the india-rubber to collapse, and so producing a change of form. In the construction of the road steamer the greater portion of the weight, including the boiler, rests upon the driving wheels; the third wheel in front is for guiding the direction of movement, and is perfectly under control.

On the first day Mr. Anderson saw it in Leith the streets were very wet and greasy. A train of waggons containing ten tons of flour, besides their own weight, were standing at the bottom of a slippery street with a gradient of about 1 in 17; to this train the little engine was attached, and away it marched as if it had no load, went up to the top of the hill, and then down on the other side, no breaks being required. After depositing its load somewhere in Leith it ran down to the Portobello seashore at the rate of 10 miles an hour. On surveying the sands, Mr. Anderson says, it seemed an impossibility that it could walk on such soft sinking ground, but it rushed through all in the most wonderful manner. It then, after returning from the seaside, removed an old boiler from the Docks to a yard at some distance. The boiler and waggon, with the fastening chains, weighed upwards of 22 tons, and the boiler on the waggon stood some 25ft high. Up to this the engine backed, then marched off with its load along the quay, over the swing bridge and along the quays, until it reached its destination. The charm of the performance, Mr. Anderson remarks, was in the way in which it was done. No shouting, no refractory or desultory pulling of horses, but by the expenditure of a few pounds of coals and water the whole was accomplished with ease and celerity; and so accustomed are the people in Leith to its performance that no notice was taken of it except by the country horses, for the town horses seem to know that it is their friend rather than their enemy.

THE PRUSSIAN NEEDLE-GUN AND THE FRENCH CHASSEPOT NEEDLE-GUN.

The following description and American opinion of the Prussian and French guns may at this present juncture be of interest to our readers:—

The construction of the Prussian needle gun, which proved so destructive during the war of 1866, is shown in Figs. 1, 2, and 3.

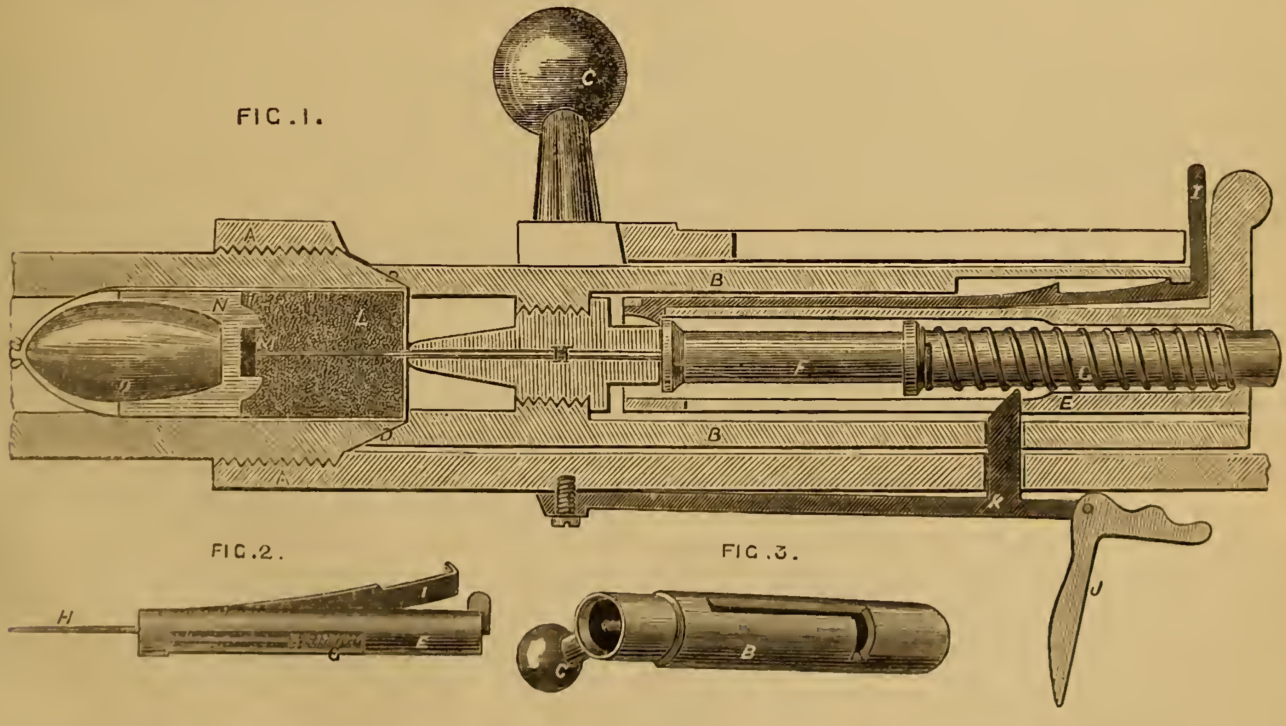
Fig. 1 represents the breech piece, with its parts partly in section, contracted longitudinally. In fact this breech piece is eleven inches long. *F*, the spiral spring, *G*, and the needle, *H*. At *H* is also a plug or guide, screwed to the inside of the chamber, *B*. On the apex of this the cartridge rests. A spring, *I*, with its end catch serves to withdraw the cylinder *E*, with the bolt, *F*. The trigger, *J*, is a bell-crank lever, which depresses the spring, *K*, and allows the cylinder and contents to be drawn to the rear. *L* is the powder, *M* the percussion wafer, *N* the *sabot*, and *O* the bullet—all enveloped in paper.

The operation of this mechanism is easily understood. The spring, *I*, being pressed, unlocks from the case, *B*, and allows the sliding back of the cylinder, *E*, so that the rear projection of the bolt, *F*, takes the spring, *K*, and the needle is withdrawn into its guide or sheath, *H*. The chamber, *B*, is then unlocked by the knob, *C*, and slid back so that the front projection of *F* catches the spring, *K*, thus compressing the spiral, *G*. The rear of the barrel is thus opened, and the cartridge can be introduced.

The chamber is then moved forward and locked against the barrel, and the spring *I*, is pressed down and the needle bolt moved forward, so that the rear projection rests against the spring, *K*, and the needle rests against the rear of the cartridge, and the piece is ready for firing. The front of the needle bolt is recessed, and receives a leather washer, designed to prevent the escape of the products of the gas combustion to the cylinder, *B*—an office it performs but inefficiently.

The following quotation from the letter of an able correspondent upon the subject sets forth its defects in a strong light:—

"The needle gun is a clumsy, unsightly, heavy, and expensive gun compared to many American breech-loaders. It is complicated in its parts, and delicate in its construction. The breech piece, which contains the breech-loading mechanism, is enormously long, extending not less than eleven inches to the rear of the cartridge chamber. The gas check performs its functions badly, as there is so much escape of gas that the gun cannot be fired one hundred rounds without being cleaned. There is also considerable escape of gas into the mechanism through the needle-hole in the face of the breech-closer. This escape of gas soon fills the chamber in the cylindrical breech-closer, which contains the needle pin and spiral spring, with a residuum of burned powder, and seriously impedes their action.



The case, *A*, is screwed to the breech of the barrel, which at this point is bored out for a cartridge chamber, to the depth of the lands or grooves in the barrel proper. Inside this case is a cylindrical chamber, *B*, furnished with a handle and knob, *C*, which can be moved along a longitudinal slot in the case, having a transverse slot inclining toward the forward or muzzle end. This chamber is convexed or bored out at the end, and fits over the conical end of the barrel at *D*. A sharp blow of the hand on the knob forces its shank into the spirally transverse slot, and effectually closes the joint at *D*. Inside the chamber is a cylinder, *E*, containing the needle bolt,

"When the cylindrical breech-closer is shoved forward, the trigger having taken hold of the needle pin from below, retains it to the rear, and thus compresses the spiral spring, so that the simple act of closing the breech cocks the piece, and it is only necessary to pull the trigger to fire it. This arrangement is a convenient one for the soldier, and facilitates the firing, but it is an objectionable feature in a military arm, because when loaded it must necessarily remain at full cock. It is true there is a means provided for locking the needle pin in this position to prevent accident, but if the soldier should forget or neglect to avail himself of it, then serious accident is liable to take place at any time.

"The ammunition for the needle gun is complicated, expensive, and difficult to make up, considerable special machinery being required for that purpose. The needle gun cannot be fired more than half as many rounds per minute as most of the American metallic cartridge guns."

Improvements have been made upon this arm which somewhat lessens the force of the above objections, but it is still undoubtedly inferior to some other breech-loaders. The general principle of its construction remains essentially that shown in the engraving.

The chassepot needle gun is considered by somo to be an advance upon the Prussian arm. Its construction is shown in Figs. 4 and 5.

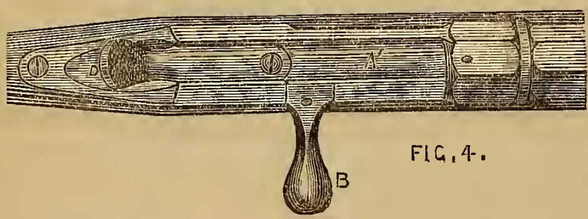


FIG. 4.

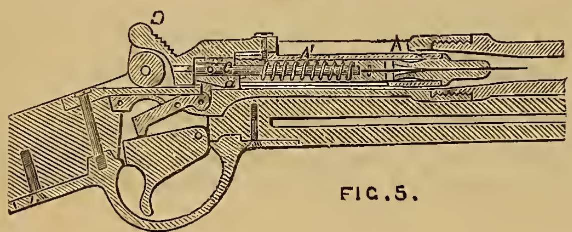


FIG. 5.

An opening on the right hand of the chamber, *A*, permits the insertion of the cartridge. This chamber is filled by the movable cylinder, *B*, which may be moved back or forward by means of the handle and knob, *B*. The cylinder, *A*, surrounds the shaft, *C*, and can be revolved around the same. It contains the spring by whieh the needle is propelled. The rear end of the shaft, *C*, is made in the shape of a handle, *D*. The spring is compressed when the handle, *D*, is drawn back. The shoulder, *a* on the shaft, *C*, comes in contact with the cylinder, *A*, when the arm is at rest. When loaded and ready for firing, the two parts are drawn asunder. The shaft, *C*, also serves to protect the needle which is surrounded by the same and is forced out of the front end of the shaft as soon as the trigger is pulled.

After the cartridge has been inserted, the knob, *B*, is pressed forward, and is then laid over to the right hand side, as shown in Fig. 4. The aperture, *A*, is now closed. By the first of these two movements the cylinder, *A*, is moved forward, thereby forcing the cartridge into the breech; the second movement secures the cylinder, so that it cannot be thrown back by the force of the explosion. The pulling the trigger releases the spiral spring, which then forces the needle through the percussion water. It is claimed that this gun cannot be clogged up as easily as the Prussian needle gun, and is more substantially built. But it is constructed on the same principle in almost every other respect.

LAUNCH OF THE "QUEEN OF THE THAMES."

On the 11th ult there was launched from the shipbuilding yard of Messrs Robert Napier and Sons, Govan, a large and beautiful iron screw steamer, named *The Queen of the Thames*, intended for the Australian passenger trade, and which has been, built for the long established house of Messrs Devitt and Moore, 109 Leadenhall Street, London. Her dimensions are 336 feet over all, 41 feet beam, and 31 depth of hold. She is built to the highest class at Lloyd's Aa 1, will be full rigged in order that she may sail as well as steam; is fitted with Napier's patent windlass, and has all other recent improvements. She is of 2607 tons register and will be supplied with compound engines of 400 horse-power nominal but capable of exerting an actual working power of 2000. Her propeller is on Griffith's principle, the blades being fitted to one boss, and all separate, so that if one should break another blade could be substituted without the vessel going into dock. It is expected that her average speed will be 13 to 14 knots per hour. She is to be commanded by Capt. Macdonald, and her crew altogether will number 120. There will be accomodation on the main-deck for 150 first-class and 100 second-class passengers, while the orlop, or lower deck, which is pierced with side lights, and 6½ feet in height, can be adapted, if required, for the conveyance of troops or emigrants.

On the upper deck forward is a house with rooms on the starboard side for the chief officer and surgeon, besides a surgery, mess-room, lamp room, and cow-house, the last lined with patent felt; and on the port side rooms for the second, third and fourth officers, the purser, chief steward, and midshipman with butchers shop, &c. The house is built of East India teak, fastened with screws, no nails being used. At its aft end is the kitchen, having an iron lining, over which are placed fire bricks; it will have the most improved appliances for cooking, and a hatch is provided through which the food will be conveyed to the main deck without having to be exposed to the upper one. In front of the house are sheep pens and fowl coops.

On the upper deck aft is the captain's room, adjoining which is the chronometer and chart room, and abaft all are the wheel house and the smoking room. An iron rail, surmounted with polished teak, runs round the deck. It is about three and a-half feet high, and will be fitted with a strong netting of rope-work, so as to prevent any one from being washed overboard.

With respect to the main deck, the chief saloon is over 100 feet in length, and no less than 9 feet in height. There are first-class state rooms on both sides, and on the port side, at the forward end, is a ladies' boudoir, which is being fitted up with much elegance. A piano is being made specially for the saloon by Messrs. Collard and Collard, London, while Messrs. Chappell and Co., Bond-street, London, furnish a harmonium which is to be used in the service on Sunday.

The second-class saloon will be furnished in a style equal to general first-class steamer accommodation. The safety, comfort, and convenience of passengers have been carefully studied. Between the first and second-class saloons are two fire-proof bulkheads, extending from the keel to the upper deck; the engine-room, outside its iron casing, has four or five thicknesses of patent felt to prevent the heat from spreading to the side rooms; and the arrangements as to baths and water-closets are of a superior character.

A feature deserving special notice is the provision, outside and forward, of the second-class saloon, of several large rooms, where 12 or 14 passengers can sleep and also mess at a lower rate.

METEOROLOGICAL REPORT.

The meteorological committee of the Royal Society, nominated at the request of the Board of Trade for superintending the duties formerly undertaken by a Government department under the charge of Admiral Fitzroy, state in their report on the work of the year 1869, that the home reporting stations have been increased by two, Wick and Thurso. A regular interchange of reports has been instituted with Norway. The drum signal is hoisted on orders from the Meteorological office at 106 British stations, and a brief explanation is sent of the reason why it is to be hoisted; the message is posted up for the information of the public. The study of weather is conducted on systematic principles, and every warning message issued is compared with the subsequent weather experienced.

The problem to which attention is now directed is the discovery of the probable path of each storm taken as a whole, and of its rate of progress across the country. The committee have sanctioned the commencement of a series of non-official papers, consisting of reports addressed to them on various questions which have been the subjects of inquiry. One of these reports, by Captain H. Toynbee, is an examination of observations taken on board Atlantic mail steamers. The diagrams of observations made by Captain J. A. Martyn exhibit this peculiarity, that when the ship is outward-bound the barometrical and thermometrical curves are marked by frequent oscillations, and the wind usually shifts from south to west and back again several times during the passage; while, when she is homeward bound, the instruments and the wind are much more steady. Captain Toynbee offers as an explanation the idea that the atmosphere over the Atlantic is in a state of constant motion in a direction which is generally easterly, and at a rate of progress slightly less than that of a full-powered steamer, and that it is disposed in a series of successive eddies or waves. The ship, when outward-bound, meets and passes through several of these systems, while on her homeward passage she may run with one for days together, and so experience little change either in wind or weather.

Should these views be confirmed by more ample experience, the generalization is calculated to be of great use, as well to scientific meteorology as to practical navigation. In regard to the land meteorology of the British Islands, the mean results of the observations in the year 1869 are in type. Measures have been adopted to reproduce the curves yielded by the instrument in fac-simile. It has been determined to publish a quarterly weather report, which shall contain the continuous plates, with a current chronicle of the weather explanatory of them. Anemometers have been erected at various points on our coasts, and observers of known accuracy have been invited to assist the office in its work.

In the department of ocean meteorology the investigation of the meteorology of the equatorial portion of the Atlantic Ocean has made satisfactory progress, as the number of assistants engaged on it has been increased. The unfinished discussions relating to the Pacific Ocean found in the office have been completed, and the results sent to the Admiralty for embodiment in their series of physical charts. The reduction of anemometrical *data* is in hand. The issue of instruments to captains on loan has been continued.

THE ROYAL AGRICULTURAL SOCIETY'S SHOW AT OXFORD.

In our last number we gave the results of the trials of the various engines entered for competition at this exhibition, where it will be seen that the results were very similar to those of previous years; in fact, but few new competitors appeared in the field, and as these were "nowhere" in the trials, the results might almost have been foretold.

Although most of the exhibits were tolerably familiar, there are several which deserve notice on account of their excellence. Thus, Messrs. T. M. Tennant and Co., of Leith, showed two of Mr. Thomson's road steamers, already noticed in The Artizan, which performed wonderful gyrations during the first few days of the meeting, but which had to be discontinued, as the ground became crowded in consequence of the danger which was a natural result of their eccentric movements. A great number of these engines have already been constructed, and many more are in hand. Mr. Charles Burrell exhibited two of his traction engines, one of 12-horse power, and another of 8-horse power, both of which were very creditable specimens of workmanship.

Messrs. Barrows and Stewart, of Banbury, were the exhibitors of a variety of steam ploughing tackle of their usual well-designed patterns, and Messrs. Amies and Barford showed examples of Mr. S. Campain's self-moving anchor, for which they were awarded a silver medal.

Messrs. John Ramsbottom and Co., of Leeds, exhibited a very curious little engine to which the name of "intermedial engine" has been given. In this engine the cylinder, which is vertical, has a length equal to rather more than three times the stroke, and it is fitted with two pistons which are kept apart by a frame. The crank shaft passes through the cylinder at the middle of the length of the latter between the two pistons, the crank being contained within the cylinder and being coupled by a connecting rod to the lower piston. Steam is admitted above the upper and under the lower piston alternately, the distribution being effected by a rotary valve fixed at the end of the crank shaft. The arrangement is specially intended for high-speed engines of very small power, and it is one which can be constructed cheaply; but we doubt whether it would be very economical in its consumption of steam.

Messrs. Crowther and Co., of Huddersfield, have sent some vertical engines with welded boilers. In these engines the boiler shell, together with the inside firebox, fire hole ring, and in some cases the cross tubes were all welded up in one solid piece, no riveting being used. As far as could be judged, the workmanship appeared to be good and sound throughout. The engines were fixed to a cast-iron bedplate bolted to the side of the boiler, and the proportions generally were good. Each engine was provided with a feed-water heater consisting of a coil of pipes contained in a chamber traversed by the exhaust steam, the feed water being pumped through this heater on its way to the boiler. One of the engines also was fitted with Hopkinson's air regulator or smoke-burning apparatus, for controlling the admission of air at the fire door.

Messrs. Ruston and Proctor had a very fine show of engines and thrashing machines, together with a very effectual jam block for engines and thrashing machines, which consists of two brake segments forced against the wheel rims by a right and left-handed screw; one of those traction or jam blocks is of course used at each side of the engine or thrashing machine.

Messrs. E. R. and F. Turner, of Ipswich, exhibited a very neat form of feed-water heater. It consists in providing the pump with a return pipe to the feed-water tub, and fitting this pipe with an internal nozzle or jet directed downwards, and communicating with the exhaust pipe of the engine. To heat the water, the feed is shut off from the boiler, and the pump caused to circulate the water through the pipe we have mentioned, when it is of course brought into contact with an induced current of exhaust steam. By this arrangement, Messrs. Turner state that they can easily heat the water in the feed tub to quite 190°, and that, at that temperature, no inconvenience is experienced in the working of the pump, as it is continually charged.

Messrs. Allan, Ransome & Co. had some remarkably fine specimens of their wood-working machinery, amongst which was a beautifully finished moulding machine, intended to work at a high speed. From the excellency of their workmanship, combined with a strict attention to the balancing of the various moving parts, a speed of 7,000 revolutions per minute is obtained without excessive wear and tear or vibration.

Messrs. Powis, James, and Co., of York-road, Lambeth, were large exhibitors, including an improved moulding and planing machine, doing four sides at once, a thoroughly well got up and substantial machine; an improved endless band-saw, and a set of very ingenious and well-constructed wheel-making machines, which shape the felloes, tang the spokes, and bore the felloes and shape the spokes.

Messrs. Charles Powis and Co., of Millwall, exhibited, among other machines, two which possess considerable novelty—one, an improved trying-up machine, made expressly for dealing with warped or twisted pieces, which leave the cutters ready for glucing up, and the other a general joiner.

Mr. William Alfred Gibbs, of Gilwell Park, exhibited one of his portable iron drying sheds, stated to be capable of drying a load of hay in twenty minutes, and also a specimen of "sheaf-tube floor" capable of drying thirty-two sheaves in fifteen minutes, together with several models illustrating his process. In the hay drying shed the process of drying is effected by lifting the hay and allowing it to fall loosely in front of a long opening, through which hot air is discharged by a fan. The hay is lifted by self-acting forks, which are raised and lowered by the engine from which the fan is driven. In drying sheaves, each sheaf is impaled on a perforated tube through which a discharge of hot air takes place.

Messrs. Davey, Paxman, and Davey, of Colchester, exhibited several examples of their steam corn-drying apparatus, which, it is said, answers this purpose exceedingly well.

There were also an enormous number of machines adapted for minor purposes, or not strictly engineering, many of which were of remarkably good workmanship, but not sufficiently novel to require notice.

NEW STEAMER FOR THE BRAZILIAN TRADE.

During the present week a new paddle wheel steamer named the *Maranhao*, built for the Maranham Steam Navigation Company, was despatched from Liverpool for the River Amazon. The Company referred to, it may be generally stated, was started by a number of Brazilian merchants, for the purpose of developing the trade of Brazil, and utilizing the immense extent of river and coasting navigation of that prolific and highly favoured region. Some idea of the importance of this navigation may be formed from the statement that the river navigation of the country amounts to the vast aggregate of fully twelve thousand miles, through valleys and plains marvellously rich in mineral and vegetable wealth; and that its sea coast extends from the equator to 23deg. of south latitude, and from 35deg. to 50deg. of west longitude; thus possessing also an immense length of sea coast. The vast area of the Brazilian Empire, all of which is tropical, and intersected by noble rivers, including the Amazon and its innumerable tributaries, besides others of scarcely inferior magnitude, is of the most abundant fertility, and offers an admirable field for the application of industry of every kind.

The Maranham Steam Navigation Company was instituted about twelve years ago, and it has proved very successful. It possesses twelve high-class steamships, the *Maranhao*, being the twelfth which they have had built. She is an exceedingly handsome and elegant vessel of 550 tons builders' measurement, being 167ft. in length, 25ft. in moulded width, and 11ft. deep in the hold. She is impelled by a pair of oscillating engines of 150 horse power, nominal, but capable of working up to 650 horse power. She was built to the order of the Company for Messrs. Fawcott, Preston, and Co., Engineers, of Liverpool, by Messrs. W. C. Miller and Sons, of Garston, near Liverpool, the engines having been supplied by the first-named firm.

On her trial trip, which took place on the 18th ult., the engines worked with the utmost smoothness and regularity, producing hardly any appreciable vibratory motion, while the vessel maintained a speed of ten knots per hour; thus proving her to be a swift as well as a comfortable sea boat. The *Maranhao*, which is intended chiefly for the passenger traffic of the Brazilian coast, has been fitted up with a full regard to the comfort and safety of passengers, of whom she has admirable accommodation for 40 of the first class, whose sleeping berths are arranged on each side of the saloon, itself a charming and elegant apartment tastefully fitted up, and well ventilated and fully lighted, as well as supplied with everything conducive to the comfort and convenience of even the most fastidious voyager. This fine vessel has accommodation for 63 second class passengers, whose comforts have also been sedulously cared for.

On the trial trip the *Maranhao* proved herself a capital sea boat, steering easily and obeying the helm readily. While she was out, experiments were made with the crown patent fuel, supplied by the Crown Preserved Coal Company. Those experiments were considered so highly satisfactory that the vessel carries out a considerable quantity of that fuel, partly for use on the voyage, and also for supplying other steamers engaged on the Maranham route.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, AND INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.

On the 9th ult. a series of joint meetings of the North of England Institute of Mining and Mechanical Engineers, and the Institute of Engineers and Shipbuilders in Scotland, was held in Glasgow in the Corporation Galleries, which had kindly been granted for this purpose by the magistrates and council of the city.

The Lord Provost commenced the proceedings by saying that he had been requested to take the chair for a short time just by way of opening the meeting, and he did so with very great pleasure, and took the opportunity it afforded him of giving them such a welcome to Glasgow as he was entitled to do on behalf of the authorities of the city. He assured them that it afforded the authorities the greatest satisfaction when they were informed of the intention of so many members of the association in the North of England to visit Glasgow; and no sooner had they been made aware of that intention than they very gladly allied themselves with the local association to make such preparations for the visit as they thought desirable. He assured them that it would be very gratifying to the citizens to find that these arrangements had been for their comfort, and that the various places thrown open to their inspection were of a kind to interest them. He had no doubt that both the commercial industries around the city and the natural scenery with which it was adorned would prove very attractive to gentlemen having tastes lying in that direction. He took leave to bid the Institute welcome to this city, and if it occurred to them that there was anything further that could be done to interest them, they had but to mention it to the local secretary and it would be attended to with pleasure. In conclusion, his lordship mentioned that it had been arranged that Mr. E. F. Boyd, president of the North of England Institute, should be president of the joint bodies during the meeting, and he would now take the chair.

Mr. Boyd expressed the thanks due to the Lord Provost, and the authorities in Glasgow, for the trouble they had taken in making the preliminary arrangements for the present meeting, and for the handsome reception that had been given in this city to the North of England Institute. He afterwards proceeded to speak of the advantages connected with such institutes, from the opportunities they gave gentlemen for combining their observations for forming comparisons on points which could not be done individually, and, by their joint contributions, to form a fund to pay the expense of printing the papers read, with contained particulars such as were not to be found in encyclopædias, dictionaries, or other scientific works. The chairman concluded by expressing the hope that the North of England Institute, in visiting Glasgow, might leave some impression behind them, and that many men around Glasgow, who had been in the habit of talking and thinking scientifically on subjects, but had not written on them, would be incited to produce papers similar to those of the Institute.

THE GEOLOGY OF THE COAL MEASURES OF SCOTLAND.

By Mr. JAMES GEIKIE, District Surveyor on the Geological Survey of Scotland.

Mr. Geikie described, first, the calciferous sandstone series, which, when typically developed, consists of a double series of strata. The lower group pointed to the prevalence of marine conditions at the time the red sandstones and conglomerates were deposited. In the upper group we have evidence to show that during its accumulation marine and brackish water conditions alternated with the occasional appearance of land surfaces. During the deposition of both upper and lower groups, volcanoes were somewhat prevalent. Second, the carboniferous limestone series, he said, consisted of three groups—1. Lower group, accumulated chiefly during marine conditions, but presenting us with occasional old land surfaces. 2. A middle group, showing frequent land surfaces with intercalated periods of brackish water and marine conditions. 3. An upper group, pointing chiefly to lower marine conditions, but showing occasional brackish-water deposits and a few old land surfaces. Throughout the accumulation of the whole series volcanoes were very active, both submarine and subaerial. Third, the millstone grit was deposited under conditions almost exclusively marine. Fourth, the coal measures showed a prevalence of brackish or fresh water conditions with abundant land surfaces, but they also spoke to us of occasional inroads of the sea. Neither in the millstone grit nor in the coal measures did any contemporaneously formed igneous rocks appear. Fifth, the intrusive rocks he divided into three classes—1. Intrusive sheets referable to the close of the "coal measures" group. 2. Bosses, or pipes of tuffa and agglomerate, which, in all probability, are of Permian age. 3. Dykes of dolerite, belonging to the period of the Miocene. Sixth, there were two systems of faults met with in carboniferous areas. The oldest faults were those which strike N.E. and S.W., and frequently form the boundaries of the carboniferous formation. The second series consisted of a double set of faults, striking approximately E. and W. and N. and S. These faults were of different ages. All were later than the age of the coal measures—some were posterior in date to the deposition of the upper red sandstone group, and anterior to the accumulation of the Permian sandstone; other faults were probably of Permian age, and a few may belong to the Miocene period. Mr. Geikie remarked, in concluding his interesting paper, that he had no hesitation in saying that, when the palæontographical and geological history of the Scottish carboniferous rocks has been fully worked out, we shall have prepared for us one of the most interesting and important chapters in the physical history of our country.

ON THE DUTY OF CORNISH AND OTHER PUMPING ENGINES.

By Mr. J. B. SIMPSON.

The writer noticed at the outset that a Cornish engine for pumping water out of mines having been erected in the Newcastle district, he was able to speak more decidedly than formerly as to the merits and results of this kind of engine. These he considered as very satisfactory, and contrasted very favourably with the result of the other engines usually employed in the Northumberland and Durham district. Having described its construction, he proceeded to indicate that the differing features of the Cornish engine from other pumping engines were as follow:—1. That it is generally worked at a high rate of expansion; 2, that there is a steam jacket attached to the cylinder; that the cylinder is covered with felt, and in addition to this, a covering of ashes or clay about one foot thick, and then a covering of brickwork to prevent radiation, and that there is a drain pipe from the jacket to carry away the water from the condensed steam to the boilers; 3, that the boilers and pipes are all arranged so that there is the least possible radiation of heat—the boilers being generally covered up with fine ashes or common clay. In three trials made with the engine to ascertain its duty, it was found that the effective duty varied from 4·4 lb. per horse-power per hour to 5 lb. When the balance-beam was attached and the arrangements completed, it was found that the effective duty was increased from 4·4 lb. to 3·6 lb., equal to a saving of 16 per cent., and which, taking the feed of water at 860 gallons per minute, would amount per annum to 420 lb., and at 4s. per ton, to a saving of 80*l.* Not only was there this saving, but also a steadier working of the engine. Mr. Simpson then entered upon an examination of the details of twelve different kinds of engines, and contrasted their merits with the Cornish engine.

The following table contains the results obtained; No. 1 being the Cornish engino referred to at the outset:—

No.	Dimensions of cylinder.	Galls. per minute.	[Horse-power effective.	Effective duty in lbs. per horse-power per hour.	Indicated duty in lbs. per horse-power per hour.	Million lbs.	Cost per annum of coals per 100-horse power of effective duty.	Percentage effect.
	in.						£	
1	70	829	149·16	3·6	2·9	61·28	283	81
2	77	1474	161·65	10·9	8·7	20·39	854	79
3	44	385	50·10	9·9	8·0	22·68	763	81
4	63½	1086	81·86	11·3	10·6	19·69	891	93
5	48	416	29·34	24·8	20·8	9·01	1940	83
6	82	191	69·29	28·5	—	7·78	2234	—
7	44	837	70·0	12·5	10·9	17·22	977	84
8	40⅜	785	71·36	16·9	13·9	13·05	1329	89
9	42	1460	98·03	10·6	—	—	849	84
10	52½	495	43·65	9·7	6·5	22·95	761	67
11	70	669	58·72	—	—	—	—	—
12	65½	324	54·16	27·4	—	6·27	2234	—

In concluding, he said:—"Taking the engines we have mentioned into consideration, we find a total aggregate effective power of 1,030-horse power applied, making an average duty of 14 lb. per horse per hour. This we believe to be the average duty of the Newcastle district. Were a duty of

4lb. obtained, the saving in these engines alone would represent 40,000 tons of coal per annum, which, at 3s. per ton, would equal 6,000*l*. We may safely assume the total horse power of engines used for pumping water in the Newcastle district at about 10,000, and upon the above basis of saving we have a very momentous sum as the result. In many places coal may not be worth so much as 3s. per ton at the pit's mouth, but in the majority of cases it will very much exceed this. We are too much inclined to think the coal at the colliery is of little or no value, and that the extra consumption of 10 lb. or 12 lb. per hour is not worth consideration. It must not, however, be forgotten that the fuel is not the only pecuniary part of the question, for additional consumption of coal means additional water, additional repairs, additional wear and tear, to say nothing of additional manual labour, and these in the aggregate are very serious items of cost. There is no doubt that more attention is being paid to these subjects than formerly, and we venture to predict that the time is not far distant when pumping and all other colliery engines will be erected with more regard to annual economy, and that the effective duty of 2 lb. or 3 lb. per horse power will be considered quite as important in them as it is now in London waterworks and in ocean steamships.

ECONOMICAL ADVANTAGES OF MECHANICAL VENTILATION.

By Mr. D. P. Morison.

The writer stated that tabulated results of experiments recently made showed that the saving effected in consumption of fuel in most cases varied from 40 to 80 per cent. in favour of mechanical ventilation. Furnaces were also liable to many other important disadvantages, such as, first, the danger of an open fire in a fiery seam; second, in cases where, in order to avoid this danger, the return air is conveyed into the upcast shaft by means of a dumb drift, the serious cost of such an arrangement, not only in the first outlay of the requisite drifts, arches, &c., but also in the amount of fresh air required to feed the furnace air, which is of no value in the workings themselves; thirdly, the serious fact that the upcast shaft, being usually heated to nearly its practical maximum, cannot, in cases of necessity (such as a sudden fall of the barometer, an unexpected occurrence of a heavy discharge of a fire-damp, or a block in the air-ways), be made at once available for an increased duty; and lastly, the inordinate wear and tear upon furnace arches, bars, and the shaft lining, whether brick casing or tubing, and in case of a coal-drawing upcast shaft, the deterioration of the ropes, guides, cages, and other plant. In no case could the furnace compete successfully with mechanical ventilation. The limit to useful temperature had been proved to exist at about 570 deg. Fahrenheit; and as to the oft-quoted limit in depth, the deepest of the English mines would still show an economy in coal in favour of the ventilator of 35 to 40 per cent. Mr. Morrison then described the results obtained by the different systems of mechanical ventilation.

COAL-GETTING MACHINE.

By Mr. Arnold Lupton, Leeds.

Mr. Lupton said that to find a substitute for the explosives used in coal mining had long been desired by many ingenious men, and the applications of the force pump naturally suggested itself. The idea of forcing a wedge into the coal by means of a hydraulic ram was suggested, but the plan was found impracticable, first, because it was almost impossible to force a wedge of sufficient size into so compact a mineral as coal: and, secondly, because it would be equally difficult to find a prop to resist the backward pressure of the ram. The system of wedging coal by first drilling a hole and then inserting two inclined pieces of steel, between which was afterwards driven a wedge by means of a sledge hammer, had been occasionally used. To substitute, in this instance, a hydraulic ram for the sledge hammer, and to find a prop for the ram by means of tension bars connecting this cylinder to the inclined pieces of steel above mentioned, was the device of Mr. Grafton Jones, which the writer proposed to describe. The machine was constructed entirely of the best hammered cast iron. The tension bars, the ram, and the cylinder were all in one piece, being cut out of a solid bar of steel. The ram was worked, not by the ordinary force pump, but by a screw pump patented by Mr. Grafton Jones. By means of this pump the force of the machine was immensely increased, the only limit to the force that might be applied being the strength of the tension bars. The advantages the writer claimed for the use of the hydraulic wedge and drilling apparatus employed in this machine were—1st, The safety with which mines may be worked with them as substitutes for gunpowder; 2nd, The superior shape of coal that had been wedged to coal that had been blown, and the less amount of slack made; 3rd, The improvement in the health of the colliers that will ensue on the disuse of gunpowder; 4th, The saving in labour by using the hydraulic wedge instead of the hammer-driven wedges; 5th, The saving in labour and diminution in the amount of slack made by using the hydraulic machine to push the coal out of the solid—that is, without any holing—in working those seams whose nature is such as to render it possible.

EXPANSIVE DOUBLE-CYLINDER PUMPING ENGINE.

By Mr. Andrew Barclay, Kilmarnock.

The improvement which the writer proposed to effect on the pumping engine was to adopt the double cylinder, which had been found so efficient for other purposes, and to dispense with the ponderous working beam, and substitute in its stead an overhanging lifting beam, thus doing away with the necessity for the expensive foundations. The principle of the engine was to admit high pressure steam from the boilers into a small cylinder, where it gives its direct power, after exerting which it passes into a large cylinder, utilising the expansive power still left in the steam. In marine or land engines fitted with double cylinders, this operation went on at both ends of the cylinders; but as the pumping engine was only required to do duty in one direction, the arrangement was different. In it the steam was first admitted to the bottom of the small cylinder. When the piston had reached the top of the stroke, the same steam was admitted at the top of the same cylinder, the engine, being then in equilibrium, descended with its own gravity. When the piston had reached the bottom of the stroke, the steam was all in the top side of the cylinder. It was then admitted under the piston of the large cylinder, where it acted with its expansive force—fresh steam from the boiler being at the same time admitted under the piston of the small cylinder. Both of the cylinders were jacketed to prevent condensation, and the other parts of the engine—such as the air pump, condenser, cataracts, &c.—were got up in the usual way. One effect of the overhanging beam, which was the chief peculiarity of the engine, was to increase the stroke from 10ft. in the large cylinder, and 7ft. 9½in. in the small one, to 12ft. in the pumps. It also dispensed in a great measure with the massive beam and masonry required to carry the beam and other parts of the Cornish engine, the force of the steam being exerted in lifting only. This engine possessed all the advantages of the beam engine, and was nearly as cheap as the direct-acting engine, while it did not close up the mouth of the pit. All the building required for this engine was a broad enough base and sufficient weight in the foundation under the cylinder to prevent it from working its way into the ground. The writer further stated that, with the same quantity and pressure of steam, the power of this engine and that of the Cornish engine were almost identical.

ON THE UTILISATION OF BLAST FURNACE GASES.

By Mr. Wm. Ferrie.

The utilisation of gases from blast furnaces had, the writer said, for many years attracted the attention of the ironmasters; and in the Cleveland district, in particular, the consumption of these gases had arrived at a high degree of perfection. In districts were raw coal was the fuel used, nothing could be stated as to the results; and it had been said that a Scotch furnace sent twice as much unconsumed fuel into the air as was consumed within it. The difficulty in withdrawing the gases from a furnace using raw coal as the fuel was that the combustion of the gases at the furnace top was the means whereby the coal was converted into coke, in which state it must be, previous to its descent to the zone of reduction. That the gases were in excess of what was required for the coking process, was beyond doubt, but to regulate the withdrawal of them so as not to interfere with the regular working of the furnace had never been done satisfactorily. Were a practicable plan introduced to admit of the withdrawal of the gases, the saving in fuel would be enormous, and amounting to something like 600,000 tons of coal per annum over the pig-iron furnaces of Scotland. In considering this subject, it occurred to the writer that, if they could coke the coal in furnaces in the same way coal was coked in the common retorts at gas works, the difficulty would be overcome. He accordingly commenced experiments with a small blast furnace, about the fifteenth capacity of a fifty feet furnace. The upper part was divided into two compartments or retorts, into which the coal, ores, and flux were charged, and the top was closed in the usual way by the bell and cone. The gases passed off into a main which communicated by two pipes, one to each side of the furnace, to the entrance of the flues at the bottom of the retorts, and were ignited by the aid of atmospheric air. These flues were constructed spirally, in order that the heat from the burning gases might permeate the materials inside of the retorts, while the exhaust gases were thrown off by chimneys at the top of the retorts. This small furnace was worked for about two months with raw coal only as fuel, and the results obtained were highly satisfactory, notwithstanding that the furnace was of so small dimensions. The iron produced was Nos. 1, 3, and 4, and that from materials that had only been sixteen hours in the furnace, so great was the rapidity of the "driving" of the furnace. An examination was daily made into the interior of the furnace at the bottom of the retorts, and invariably the coal was found thoroughly coked and at a high heat, the lime completely calcined at the same temperature, and at a like temperature also were the coals. Being convinced that this plan of working a furnace was practicable, operations were immediately commenced for altering one of the ordinary furnaces at the Monkland Ironworks on the same plan or nearly so. Mr. Ferrie, with the aid of diagrams, described this furnace, and also another modification of a self-acting coke furnace. The throat of this furnace was contracted in diameter, whilst of a proportionally increased vertical length, so as to form a single retort which was heated by burning gases surrounding it. He proposed to introduce a portion only of the coal, or, it might be, of coke, into the central retort, along with the ores and flux. The retorts at the outside of the lining were to receive the remainder of the coal which became coked in descending the retorts, which were heated by burning gases in flues surrounding them. These retorts were continued downwards separately from the central part of the furnace nearly to the hearth, so as to keep their contents distinct and to ensure the coke formed in them being interposed at the hearth between the ores or metal and the blast jets. This plan of furnace was intended to secure that the coke should be at all times between the blast and the ores, and the wiiter anticipated from such an arrangement an increase in the production of carbonic oxide, a regularity in the smelting process, and a saving of fuel. He had not, however, had the opportunity of putting such a furnace in practice, but he was iu the meantime altering a furnace with the view of making the experiment.

MINERAL OIL WORKS.

By Mr. David Cowan.

The oil-yielding materials—that is, the bituminous shales and the cannel coals—the writer said, were plentifully distributed throughout the whole of our Scottish coal measures, but differed very much in character both as regards the quautity and quality of the produce. To obtain oils from those materials, they were first subjected to a process of destructive distillation, which forms the oils, during which they escape in the form of vapours, while the fixed carbon remains, with the ash, in the distilling vessel or retort. The economy and efficiency of this operation depended greatly upon the kind of retort, the system of heating adopted, the degree of heat applied, and the effectiveness of the condeusing part of the appaiatus. After giving descriptions of the horizontal and vertical retorts used in the Glasgow district, and discussing the advantages and disadvautages of each, he went on to indicate an arrangement of apparatus designed to combine the advantages of both. The arrangement proposed belonged to the vertical class, with improvements calculated to remedy the evils attaching to the vertical retorts at present in use. The apparatus necessary was fully described, and it was stated that the vapour did not require to ascend at all—that although it might partially condense within, it could not return to the hottest part, but must pass downwards to the condensers; and therefore, whatever loss was due to the decomposition, which was usual from this cause, would in a great measure be saved. As to the mode of heating the retorts, it was suggested that, instead of firing with coal, the retorts should be heated with gas flame, as, besides economising fuel and labour, it would meet the requirements of regularity and watchfulness more satisfactorily than the present system; and, further, that the system of first converting the fuel into gas (so successfully worked up by Siemens) should be adopted. This mode of heating by gas instead of by solid fuel and with hot air supplied to the furnaces should, besides the other more important advantages of regular temperature, effect a saving of from 40 to 50 per cent. of the fuel. The author had also directed his attention towards economising the labour required for charging and discharging the retorts, and with this object in view he had designed an arrangement of machinery for serving the materials to the retorts, which he described along with the other parts of the plant.

ON THE MAGNETIC IRONSTONE OF ROSEDALE ABBEY, CLEVELAND.

By Mr. John Marley, Darlington.

The author stated that he had read a paper on the "Cleveland Ironstone" before the Institution of Mining Engineers thirteen years ago, and that since that time various other persous had followod on the same subject, two or three of them dwelling more especially upon the extraordinary deposit of magnetic ironstone at Rosedale Abbey, or what is now locally termed Rosedale West. During the last eleven years extensive explorings and workings have been carried on at Rosedale, sufficient to justify the preparation of a paper devoted to the magnetic ironstone deposit of itself. The author paid a visit to Rosedale in June last, after having seen an article on "Boring and Blasting" in Spon's "Dictionary of Engineering," containing some remarks reflecting on geologists for basing the conclusions of geological science upou the evidence obtained by the system of boring for minerals, "ou which," accordiug to the editor of that work, "the so-called science of geology is made to rest," and which is, iu his opinion, a "baseless fabric." One of Mr. Marley's reasons for bringing forward the subject was to do justice to Mr. Nicholas Wood, and the late Mr. Bewick, both of whom took a prominont part in the discussion which led to the reflections made in Spon's "Dictionary."

In addition to Mr. Marley's paper of 1857, the principal authorities on the Cleveland ironstoue generally, as also upon the peculiar deposit of magnetic ironstoue at Rosedale Abbey, are the following:—Mr. Bewick's paper, read before the Newcastle Institute, 1857; Mr. N. Wood's paper, read before the Newcastle Institute, 1859; Mr. T. Allison's paper, read before the South Wales Institute, 1869; Mr. Cockburn's paper, read before the Cleveland Institute of Engineers, 1869; and the work published by Mr. Bewick on the "Cleveland Iroustone" in 1860.

In Mr. Marley's paper of 1857 it was deemed necessary to refer to the Rosedale deposit on account of its great extent, the large percentage of metallic iron contained in it, and the magnetic properties of the stone. It was only in 1834 that attention was directed to it in modern times, and yet 600 years ago iron had been made at Rosedale. In 1853 attention was directed to the stone for ironmaking, and two years before that time it was largely worked for making and repairing roads. Both the superficial area and the depth of the deposit were improved in 1867, when the stone was believed to be in a conglomerate state and not stratified; and at that time attention was directed to a check or slip running parallel to the drift. The writer had no doubt, then, that "Sheriff's Drift Seam," about 13 ft. thick, was the top seam of ironstone of the Lias formation, a supposition which is now found to be correct, as the Cleveland top seam actually overlies the magnetic stone, but the percentage of iron in tho stone and the quality of the ore both differ in the two contiguous mineral masses. There are still some things undecided regarding the magnetic deposit, but it certainly cannot be called either a "vein" or a "bed." The extent was unknown in 1857, but it is now estimated pretty accurately. Before it is calcined the ore is strongly attracted by the magnets, but only in exceptional cases does it attract iron itself. In the best specimens the ore contains 42 to 50 per cent. of metallic iron, but in the Cleveland main seam the amount varies from 33 down to 28 per cent., while the top seam of Rosedale East contains 35 per cent. and upwards of metallic iron. Mr. Marley quoted at considerable length from the papers of Mr. Wood and Mr. Bewick, the opinions of those gentlemen on the nature of the deposit, and from Mr. Allison's paper the following extract:—"This is the most singular deposit of iron ore in Cleveland, or even in England, inasmuch as its deposition does not appear to have been governed by any known law. We must therefore confess our ignorance, and call it the act of onc of Nature's unknown bye-laws." The ore is localised in two troughs, one of which is 90 feet deep; each haviug an area of about five or six acres, or only about one-fifth of the area which the borings were at first said to indicate. As illustrated by means of longitudinal and cross vertical sections, and isometrical drawings of the deposits of ironstone in the two troughs, the latter do not touch, as was stated by Mr. Allison, and their sides are irregular and shelving. Mr. Wood did not doubt the accuracy of the statements made regarding the drifts and borings on which he based his opinions as to the extent of the magnetic ironstone; from information which is now obtained, the extent of the ore would have been at once definitely proved, it is quite evident, if his original advice had been adopted, namely, to drive north and south cross-cuts when about 300 yards in. When the drifts got in 400 yards they came upon a shale check in front, which was also proved on each side of both troughs. When this was followed up it was found to be the end of the magnetic ore to the west, and simultaneously there was found a slip dyke riser to the west. On the top of this dyke there was an isolated patch of magnetic ore, and between it and the top seam of the district there were found pebbles and shells, similar to others which are found in these two deposits, between the said top seam and the magnetic ore, and sometimes on the side of the shale check. A slip dyke quarry, which was frequently spoken of by Mr. Wood and Mr. Bewick, seemed to be nothing more than a landslip of the hill-side. The termination of the magnetic stone being determined, a drift of about 300 yards was run up to No. 2 bore-hole, in the hope that on reaching it the two magnetic beds would be got instead of the one lost; the result was that common shale was found *in situ* above, while below there were sandstone and shale. In neither direction was there magnetic stone as had been alleged. Various observers had been misled by the fact that magnetic stone had got into the borehole, forming an "artificial deposit." The writer declined to enter into the consideration of the questions—how Nature deposited the magnetic ore in the troughs, and how the troughs themselves were formed. On the question of the cause of the magnetic quality of the stone, it was mentioned that the troughs lie east and west. Icebergs and glacial deposit were, in the author's opinion, in no way connected with the induction of the magnetic state, nor yet with the formation of the troughs. The deposits are not two beds of regular strata; nor are they veins, as no fissures have yet been found at the bottom of the troughs, although they have been diligently looked for. Since April, 1861, these troughs have yielded about three quarter million tons of stone; there is still a considerable quantity of magnetic ore, but the annual yield cannot be great henceforth. Fortunately, as some solace for the disappointment, the top seam of the district is of extra richness.

Death of Sir John Thwaites.—We regret to have to announce the death of Sir John Thwaites, the chairmau of the Metropolitan Board of Works, which occurred on the 8th ult., at about three o'clock in the morning, at his residence, Meaburn House, Upper Richmond-road, Putney, after an illness of a few days' duration. Sir John Thwaites was in his 56th year, and had been chairman of the Metropolitan Board since its formation in 1856, previously to which time he was one of the Metropolitan Commissioners of Sewers. Sir John was a magistrate of the counties of Surrey and Middlesex, and a deputy-lieutenat of the latter county.

INDIA PUBLIC WORKS DEPARTMENT EXAMINATION.

(*Concluded from page* 189.)

July 5, 1870; 10 a.m.—1 p.m.

LOGARITHMS, TRIGONOMETRY, MENSURATION.

1. Calculate by logarithms the value of

$$(32\cdot725)^{11} + (.0349)^{9} \div \sqrt[3]{(76\cdot1)^{5}}.$$

2. Solve the equation $\sqrt[x]{124} = 7$.
3. Given log 2 = ·3010300, log 3 = ·4771213;

find the logarithm of $\sqrt[5]{(7\cdot1)^{5}}$.

4. The angles of a triangle are in geometrical progression, and the greatest angle is equal to four times the least; express the angles in French grades, minutes and seconds.
5. Given sec A = 1·6; find the other trigonometrical functions.
6. A staff at the top of a tower is observed to subtend an angle of 15 deg. by an observer at a distance of 36ft. from the foot of the tower, and also to subtend the same angle when the observer has removed to a distance of 28ft. further from the tower: find the height of the staff.
7. In any triangle A B C the tangent of half the difference of the angles B and C is to the tangent of half their sum as the difference of the two sides A B and A C is to their sum.
8. Being on a river, and observing a column on the banks, I find the angle of elevation of its top to be 30 deg., and the angle subtended by its top and a small island down the river to be 47 deg. 25 min. After sailing past the column to this island, a distance of 450 yards, I find the angle subtended by the top and my former position to be 18 deg. 30 min. Find the height of the column.
9. The vertical angle of a triangle is 120 deg., and the difference of the sides is equal to $\frac{3}{5}$ths of the base; find the other angles.
10. Express the cosine of the sum of two angles in terms of the sines and cosines of the angles themselves; with proof.
11. A regular polygon of n sides is described about a circle of given radius find the area of the polygon.
12. A railway cutting is to be 25ft. deep, and to have a breadth of 30ft. at the bottom; find the width at the top so that the sides may have a slope of 30 deg. from the vertical. In 100ft. of such cutting how many cubic yards of material must be removed?
13. In a circle of 10ft. radius is inscribed a triangle whose angles are 45 deg., 60 deg., 75 deg.; determine the areas of the segments exterior to the triangle.
14. The circumference of the base of a conic frustrum is 50ft., the altitude 16ft., and the diameter of the top 13ft.; find the whole surface and the volume.
15. Show how to divide a 2ft. globe into three portions of equal volume by parallel planes.
16. If a circular arch, composed of five rings of brickwork, have a clear span of 30ft., and measure 37ft. on the back; find its rise, and the area of its face, supposing the depth of each brick to be 4½in.

July 5, 1870; 2 p.m—5 p.m.

STATICS, DYNAMICS, HYDROSTATICS, &c.

1. Enunciate the "Parallelogram of Forces" and the "Triangle of Forces." The resultant of two forces is 21lb.; one of them is 14lb., and the other is inclined to the resultant at an angle of 30 deg.: find the other force, and the angle between the two. Can the forces represented by 12, 4, 7 acting on a particle keep it at rest? Give the reason for your answer.
2. The arms of a straight lever are 11in. and 13in.; and from their extremities weights of 7lb. and 8lb. are respectively suspended; at what point must a weight of 3lb. be suspended that the lever when horizontal may be in equilibrium.
3. State and prove the rule for finding the centre of gravity of a triangular pyramid.
4. From a cylinder, let a cone having the same base and altitude be cut out; determine the centre of gravity of the remaining part of cylinder.
5. In a system, where three pulleys hang by separate and parallel strings, a weight of 3lb. is attached to the highest, 4lb. to the next, and 5lb. to the lowest pulley: find the power required to sustain equilibrium.
6. The length of a screw is one foot and a-half, and the radius of the cylinder one-twelfth of that length: if the thread makes thirty-six turns, find its inclination and length.
7. Find the force along a horizontal plane required to draw a weight of 25 tons up a rough inclined plane, the coefficient of friction being ·416, and the inclination of the plane being such that 7 tons acting along the plane would support the weight if the plane were smooth.
8. Enunciate the first and second laws of motion. A body starts with the velocity u, and is acted on by a uniform force in the direction of the velocity during the time t; if f be the acceleration, and s the space described in the time t, prove that $s = ut + \frac{1}{2}ft^2$; and if v be the velocity after describing the space s, prove that $v^2 = u^2 + 2fs$.
9. A particle uniformly accelerated describes 108ft. and 140ft. in the fifth and seventh seconds of its motion respectively: find the initial velocity and the numerical measure of the acceleration.
10. Two weights of 5lb. and 4lb. together pull one of 7lb. over a smooth fixed pulley, by means of a connecting string; and after descending through 15ft. the 5lb. weight is detached without interrupting the motion: find through what space the 4lb. weight will descend.
11. A body impinges directly on another: find the velocities after collision, the elasticity being imperfect.
12. A stone of 2lb. weight is whirled round horizontally by a string 5ft. long having one end fixed: find the time of revolution when the tension of the string is 5lb.
13. A railway truck weighing with its contents 10 tons, resistances being 8lb. per ton, is drawn from rest by a horse; after going 300ft. it is observed to be moving at the rate of 5ft. per second: determine the number of units of work that has been done by the horse.
14. The sides of a rectangle immersed vertically in water are 7 and 12, the shorter side being coincident with the surface: it is required to draw from one of the angles at the surface a straight line to the base dividing the rectangle into two parts, such that the pressure on them may be as 5 : 3.
15. A hollow copper sphere, whose internal diameter is 2ft. just floats in water: find its thickness, the specific gravity of copper being 8·788.
16. Describe the barometer. In the tube of a barometer 34in. long some air was left, and the mercury was observed to stand at 28in., when in a perfect barometer it was at 30in.: suppose, on the top of a mountain the perfect barometer stood at 20in., at what height would the imperfect barometer stand?
17. Describe the thermometer, the mode of filling it with mercury, and the process of graduating. Express the temperature 98 deg. Fahrenheit in terms of the centigrade and of Reaumur's thermometers respectively.
18. Find the height through which water will rise in the pipe of a common pump after any stroke.

MANCHESTER STEAM USERS' ASSOCIATION.

CHIEF ENGINEER'S MONTHLY REPORT.

The last ordinary monthly meeting of the Executive Committee of this Association was held at the Offices, 41, Corporation-street, Manchester, on Tuesday, July 26th, 1870, Sir William Fairbairn, Bart., C.E., F.R.S., LL.D., &c., President, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, which on that occasion was for two months, and is given in abstract as follows:—

"During the past two months 485 visits of inspection have been made, and 1,106 boilers examined, 668 externally, 23 internally, 13 in the flues, and 402 entirely, while in addition 11 boilers have been tested by hydraulic pressure. Five of these hydraulic tests were ordinary ones, simply to ascertain the sufficiency of boilers already in work, while in the other 6 cases the boilers were new ones, and were tested by hydraulic pressure, as well as specially examined, both as regards their construction and complement of fittings, before leaving the maker's yard. In the 1,106 boilers examined, 207 defects were discovered, 14 of them being dangerous. Furnaces out of shape, 4; fractures, 50,—5 dangerous; blistered plates, 13,—2 dangerous; internal corrosion, 48,—3 dangerous; external ditto, 20—2 dangerous; internal grooving, 23; external ditto, 7; feed apparatus out of order, 2,—1 dangerous; water gauges ditto, 15; blow-out apparatus ditto, 6; safety-valves ditto, 3,—1 dangerous; pressure gauges ditto, 8; boilers without pressure gauges, 1; without feed back pressure valves, 7.

"EXPLOSIONS.

"On the present occasion I have to report the occurrence of 18 explosions, by which 12 persons have been killed, and 20 others injured. Not one of these explosions sprung from boilers enrolled with this Association. In nine cases the scene of the catastrophe has been visited by one of the officers of this Association, and detailed particulars taken. As on all previous occasions, investigation has shown that these catastrophes, whatever their results, have sprung from the simplest causes. Thus, six were due to malconstruction, one to external corrosion, one to internal corrosion, and one to shortness of water, while, of the four others, sufficiently minute particulars have not been received to allow of a positive opinion being formed.

"Further details of the cause of these explosions are given below, though it has been found necessary to give them in a somewhat briefer shape than usual, on account of the length of the list, and other business to be laid before the present meeting of the Committee.

"It may be added that during the first half of this year, *i.e.*, from the 1st of January to the 30th of June, 25 explosions took place, killing 47 persons, as well as injuring 49 others,* which corroborates the estimate already given that there occur every year on an average 50 explosions, killing about 75 persons. The following is a tabular statement for the past two months:—

* One of the persons injured in the case of No. 14 explosion, referred to in the last report, died since the return was made up, so that the explosion has resulted in the death of 13 persons, as well as in serious injury to five others.

TABULAR STATEMENT OF EXPLOSIONS,

From May 28th, 1870, to July 22nd, 1870, inclusive.

Progressive No. for 1870.	Date.	General Description of Boiler.	Persons Killed	Persons Injured	Total
15	May 27	Auxiliary or Donkey. Interually-fired	2	0	2
16	May 28	Particulars not yet fully ascertained	0	0	0
17	June 2	Single-flued, or "Cornish." Internally-fired	2	1	3
18	June 6	Single-flued, or "Cornish." Internally-fired	0	0	0
19	June 9	Double-flued, or "Lancashire." Internally-fired	0	1	1
20	June 9	Particulars uot yet fully ascertained	0	7	7
21	June 17	Double-furnace, or "Waist." Internally-fired	2	1	3
22	June 17	Vertical Portable. Internally-fired	0	0	0
23	June 21	Plaiu Cylindrical, Egg-ended. Externally-fired	2	3	5
24	June 24	Upright "Furnace." Full particulars not ascertained	0	3	3
25	June 27	Double-flued, or "Lancashiro." Internally-fired	2	1	3
26	July 2	Marine: Double-furnace, Return flue Iuternally-fired	0	1	1
27	July 3	Plain Cyliudrical, Egg-ended. Externally fired	2	2	4
		Total	12	20	32

"No. 15 Explosion, which happened at about half-past five on the afternoon of Friday, May 27th, killing two persons, sprung from the boiler of an auxiliary or donkey engine employed on board a passenger steamer, below decks.

"This boiler was not examined by an officer of this Association, but it is reported that the explosion arose from the rending of the internal casing of the firebox from overheating of the plates consequent on shortness of water.

"At the inquest it was stated that this shortness of water and cousequent overheating arose through the blow-out tap being left opeu through oversight, and that against such oversights science could provide no remedy, so that the explosion was accidental.

"Not having received a detailed report on this catastrophe, I offer the following remarks thereon with some diffidence, but it appears important to point out that before the view can be accepted that modern science is powerless to prevent such explosions, it must be proved that all its appliances have been exhausted. Was such the case in the present instance? As blow-out taps have been found occasionally to be left open through oversight, they are sometimes equipped on board ship with a guard, arranged so as to prevent the key being withdrawn unless the plug be turued so as to close the tap. Again, to give warning of shortness of water, from whatever cause that may arise, fusible plugs adapted for marine boilers may be employed,—not those attached to the crown of the furnace which for many reasons are objectionable on board ship, but those fixed at the end of a pipe carried up from the boiler as already explained in the Association's printed reports for January, 1865, and November, 1869. Before therefore it can be concluded that such explosions are unavoidable, it must be asked whether these two simple appliances, in such common use elsewhere, have received a fair trial. If not, it cannot be considered that such disasters are accidental, but that there is every reason to conclude that they might be prevented by efficient boiler mountings.

"No. 16 Explosion, by which, fortunately, no one was either killed or injured, though the premises were set on fire and considerable damage done to property, occurred on Saturday, May 28th, at a bleach works. The boiler appears to have been a new one, but in this instance the scene of the catastrophe has not been visited by an officer of this Association, so that at present no reliable particulars have been obtained.

"No. 17 Explosion, by which two persons were killed and one other injured, occurred at about twenty minutes after twelve o'clock noon, on Thursday, the 2nd of June, at a saw mill, and arose from the collapse of the furnace tube of a Cornish boiler. The tube, which was not strengthened with any encircling hoops, flanged seams, or other approved means, being too weak for the pressure at which it was worked.

"No. 18 Explosion, by which, fortunately, no one was either killed or injured, took place at about a quarter-past eight o'clock on the morning of Monday, June 6th, at a colliery, and arose from the failure of the furnace tube of a Cornish boiler, immediately over the fire, through weakness caused by malconstruction.

"No. 19 Explosion, by which one person was injured but fortunately no one killed, occurred at a few minutes before six o'clock on the morning of Thursday, June 9th, at a shoddy mill, and arose from the failure of the external shell of an ordinary Lancashire boiler, at the bottom, in consequence of the plates being wasted by external corrosion to the thickness of about one-sixteenth of an iuch.

"No. 20 Explosion, by which seven persons were injured, but fortunately no one killed, occurred on Thursday, June 9th. In this instance the scene of the catastrophe has not been visited by an officer of this Association, and but few particulars have been obtained, but it is reported that tho explosion was due to shortness of water caused by the neglect of the attendant, for which he was taken before the magistrates, who committed him to gaol with hard labour for three months.

"No. 21 Explosion, by which two persons were killed and one other injured, occurred at about six o'clock on the morning of Friday, June 17th, at a cotton mill, and arose from the rupture of the bottom of the combustiou chamber, in a pateut oval-flued boiler through weakness consequent on malconstruction. The particulars of this explosion are important, and will be given more in detail as soon as opportunity permits.

"No. 22 Explosion, by which fortunately no one was either killed or injured, occurred at about half-past five o'clock on the afternoon of Friday, June 17th, at an iron ship building yard.

"It is not easy to give the cause of this explosion in a word. The boiler, which was a small one of the vertical cylindrical internally-fired portable class, employed for driving a crane, failed both in the internal casing of the furnace and in the outer shell, the firebox collapsing and the shell rending. It is difficult now to say which rent primarily and which secondarily. There was no evidence of shortness of water or of undue pressure, but it is possible that the firebox, though nominally circular, was not truly so, and hence the collapse. As the boiler had not been examined since set to work 20 moths ago, on the premises at which it exploded, such a defect might have existed without detection. Without pronouncing a positive opinion on the cause of this explosion, it may nevertheless be used as an argument in favour of carefully examining all boilers before considering them safe, since this was one of such simple construction, of such moderate size, and worked at so moderate a pressure, that it might well have been considered as perfectly harmless.

"No. 23 Explosion took place at about ten minutes past six o'clock on the evening of Tuesday, June 21st, at an iron works, and arose from the failure of a plain cylindrical externally-fired boiler, at a longitudinal seam of rivets over the fire, at which repeated repairs had been executed.

"The facts with regard to this explosion are of interest, and demand more than a passing notice. It appears that a competent independent inspector had examined this boiler in 1864, at the request of the owners, and condemned it as unsafe at the pressure at which it was worked. In 1868 the same inspector examined it again with the same result, but the boiler was worked on at the prohibited pressure nevertheless. In 1870 it burst, killing two people.

"At the inquest three engineers were found who after having made a careful examination could not account for the explosion, and thought the boiler was perfectly safe at the pressure at which the owner worked it, and that 'he exercised a wise discretion in so doing,' notwithstanding that the boiler had been burst in consequence, and that they were then engaged in investigating the deaths of two persous killed thereby. The jury returned a verdict of 'Accidental death,' but in spite of the evidence given by the three engineers just referred to, stated that they considered the owner had committed an error in judgment in working the boiler at the pressure he did after he had been advised by the independent inspector already referred to, to reduce it. To those who are endeavouring to solve the problem of making efficient periodical boiler inspection general throughout the country, such an explosion and such evidence are pregnant with instruction.

"No. 24 Explosion, by which three men were injured, but fortunately no one killed, happened on the morning of Friday, June 24th, at an iron works. The scene of the catastrophe has not been visited in this case by an officer of the Association, and I am at present provided with but few particulars.

"No. 25 Explosion, by which two persons were killed and one other injured, occurred at about half-past eight o'clock on the morning of Monday, June 28th, and arose from the collapse of one of the furnace tubes of a Lancashire boiler through weakness, the boiler being worked at too high a pressure for the strength of the flue tube, which was not supported by any flanged seams, encircling hoops, or other suitable appliances.

"No. 26 Explosion, by which one person was injured, happened on the evening of Saturday, the 2nd of July, on board a steam tug, and arose from the collapse of two of the flue tubes, which were oval in section and imperfectly stayed. The boiler was evidently of very weak shape, and only adapted for low pressure but what the working pressure was could not be ascertained by the officer of the Association, who visited the scene of the catastrophe, as the fittings had been removed prior to his examination, and the fireman refused all information. But whatever the pressure may have been, the boiler was clearly too weak to withstand it, and hence the explosion.*

"No. 27 Explosion, by which two persons were killed and two others injured, took place at about half-past four o'clock on the afternoon of Sunday, the 3rd of July, and arose from the failure of a plain cylindrical externally-fired boiler, at the first belt of plate reckoning from the firing end, consequent on the ravages of internal corrosion, which so ate away the plate as to reduce it to the thickness of one-sixteenth of an inch. Competent inspection could not have failed to have detected the corrosion in time to have prevented the explosion.

"L. E. Fletcher, Chief Engineer."

NORTH BRITISH ASSOCIATION OF GAS MANAGERS.

The ninth annual General Meeting of this Association was held in the hall of the Royal Scottish Society of Arts, 117, George-street, Edinburgh, on Wednesday, the 20th July, 1870; Mr. Thomas Whimster, engineer, Gas Works, Perth, President, in the chair.

President's Address.

Gentlemen,—The duty of addressing you to-day, if it be a duty, is one which conventional usage alone has created, and the question as to whether you would be more honoured in the breach than in the observance of it on the present occasion, is one which has exercised me not a little. Yet, rather than shrink from any work which might fairly be regarded as belonging to the honourable position to which you elected me, viz., the presidency of this Association, I have ventured upon a task for which I have no great confidence in my fitness.

It is well, at these, our annual meetings, that inquiry should be made into the state of the Association, so as to ascertain whether it be in a healthy and progressive condition, and I am glad to say that, in this matter, there is room for congratulation. The number of names added to our roll of membership to-day is twelve, showing an increase of over 10 per cent. on the current year. There is also another manifestation of vigorous life in the Association this year. I refer to the prizes offered for essays by Messrs. Bartholomew, of Glasgow, Macrae, of Dundee, Fraser, of Inverkeithing, R. and J. Laidlaw, of Glasgow, and Hurll, Young, and Co., of Garnkirk. These gentlemen deserve the esteem of their fellow-members, and, I may say, of all who hold property in gas works, for their disinterested enterprise. I have no doubt that their aim in this spirited movement will be entirely successful, and that they will thus evolve the latent knowledge and utilitarian resources of the profession to an extent far exceeding what may have been anticipated. The essays sent in are few in number, and some of them too short to be of any practical value. This need not occasion surprise, as the idea of offering prizes did not occur until after the general meeting last year, and the circulars were not issued till January this year. The matter was thus placed before the managers throughout the country at their busiest season, and many of them would not have time fully to consider it, until it would be too late for them to undertake such a task with any hope of success. This was unfortunate, but as the opportunity is to be repeated, it is to be hoped that more of the members will be prepared to compete. The fact that those essays which have been sent in have been prepared upon so short a notice speaks well for the spirit of the writers. Two of the essays have been selected for prizes; one or these is a most creditable production, and the first prize was most heartily and unanimously awarded it by the committee.

Some three or four years ago, the demand for paraffine oil, coincident with the expiry of the patent of Mr. Young, of Bathgate, suggested the idea that gas companies might profitably become manufacturers of that important article, as, in the process of the distillation of coal for the production of oil, a considerable quantity of rich gas was necessarily made, it was thought that this gas might be stored for illuminating purposes. This idea was carried into practice by the Hawick Gas Company, and for a time promised to be a successful speculation; but the fluctuation in the price of paraffine, from reasons so obvious that they need not be particularised here, and to which gas is not subject, showed that this plan, though to some extent an economiser of coal, was not a safe one for gas companies, and the success of the experiment was, happily, sufficiently temporary to prevent the example being followed by more important companies, and on a larger scale. This is one of these ideas which look so very feasible before experience has disclosed their weak points, that it is not unlikely to be revived from time to time, and to prove a cause of uneasiness to gas companies.

About the same time the revival of the oxy-hydrogen light "Will-o'-the-Wisp," accompanied, as usual, by the most confident and reckless assertions, and, above all, backed by the Government of the day, in the now notorious Perth Barracks case, turned the attention of holders of stock in gas works to its threatening glare, and no doubt to some extent gave feeling of insecurity in gas stock throughout the country. In that case the statements made by interested and by no means over-scrupulous parties, were eagerly manipulated by the talented artists of the newspaper press, until the old-fashioned but "beautiful-for-ever" chemical experiment threatened to become like the tree which Nebuchadnezza saw in his dream, which filled the whole earth. I will not trouble you with details of this sham, in which Government money was freely spent in order to frighten the Perth Gas Company. Suffice it to say that it was a nine days' wonder, and was withdrawn as quietly as possible. These disturbing causes, though they do not look very formidable in the light cast upon them by their failure, are, nevertheless, while they are in operation, very troublesome, and have the effect of temporarily retarding the progress of improvement. There is the fear engendered that gas property may be destroyed by the introduction of some cheaper illuminating agent, and improvements which would be otherwise pushed forward are delayed until the fear is dispelled and confidence restored. At the present time there seems to be great confidence in the permanent value of gas stock, which is more especially manifested in the eagerness of municipal authorities to acquire the gas works throughout the country.

The illuminating power of gas test is receiving very great attention at the present time, and it is to be hoped that some practical and decisive solution of the difficulty will be arrived at. No one seems satisfied with the sperm candle as a standard of comparison, and certainly if we compare experiments made therewith, the variable results obtained are not a little confusing, and indicative of a source of error in the present mode of testing so active that little reliance can be placed in them. But it is probable that there are other and greater sources of error in the present system of testing for the illuminating power of a gas than what is found in the variable consumption of a sperm candle. Indeed, the candle seems to be the "scapegoat" in this case.

I have found that gas tested with the same candle and with the same burner will give widely different results under different conditions. Take the following trials in illustration, noting that they were all made with the same burner—a No. 6 union jet, and that they were all corrected to the standard consumption of 5 cubic feet per hour. No. 1 was made with the burner regulated by the stop cock in the usual way, immediately under the jet socket, and adjusted to a consumption of 2·69 cubic feet of gas per hour. The result obtained was 28·6 candles, the duration of one cubic foot with a 4 in. flame, being 70 minutes. No. 2 was regulated by the same stop cock with as much gas turned on as the burner would consume without rushing in the flame or smoke, and the consumption of gas was at the rate of 4·2 cubic feet per hour. The result then obtained was 31·03 candles, the duration being the same, viz., 70 minutes. I then set the stop cock full open, and adjusted the governor to give a full flame at the burner without rushing or smoke, and got a consumption of 5 cubic feet per hour. This gave a much better result in candles, but the light varied so much, in consequence of the unsteadiness of the meter, that the experiment could not be trusted. No. 3 was made with a stop cock regulated by a screw and pinion, and placed upon the pipe between the governor and the burner, and about 18 in. distant from the latter. This gave a steady full flame at the burner without any rushing or smoke; the consumption was 5·02 cubic feet per hour, and the average illuminating power in candle was 33·6, the duration test giving 69 minutes. This proves that one great source of error arises from the quantity of gas consumed, the error in this case amounting to five candles. Another, and an admitted source of error, is a rushing or smoky flame, which will seriously

* Since the above was in print, I have been informed that it has transpired that the usual pressure was about 25 to 30lbs., but that the engine man was in the habit of hanging "a bucket of water or anything handy" on to the end of the safety-valve lever. It is likely that legal proceedings will be taken, and further information may come out at the trial.

influence any experiment. I think that this view of the causes of the irregularity in the illuminating power test will be supported by the following observations on the duration test.

In experiments made during the present year, I have found that the duration test does not vary, in consequence of the size of the orifice in the burner used. Thus, burners with the openings of the size to give a 4 in. flame with 4, 8, and 16-10ths of an inch of pressure respectively, all give the same duration of a cubic foot of the same gas, as the following table of experiments will show :—

Pressure at gasholder in inches.	Pressure at burner in inches.	Time required to consume 0·1 cubic feet of gas in minutes.	Time required to consume 1·0 cubic feet of gas in minutes.
		min. sec.	
1·7	1·6	6 50	68·3
1·7	0·8	6 51	68·5
1·7	0·4	6 50	68·3

Each of the results in the third column is the average of three experiments.

Keeping this, then, in view, viz., that a 4 in. flame of the same gas will give the same duration, whatever pressure be required to produce it, let us look at the results of experiments, as published in the analyses of the many varieties of cannel coals, in which the duration test and the illuminating power test are placed side by side. A comparison of the subjoined extracts from these analyses will show a discrepancy to the extent of over eight candles, supposing that the duration test is reliable, which I take it to be.

Duration of 1.0 cubic feet of gas with a flame of 4 in. high. Minutes.	Illuminating power of same gas in candles.
64·	24·19
64·23	21·35
66·5	32·47
67·8	24·11
73·5	25·72
73·56	28·89
77·	32·15
82·9	33·
83·3	39·5
86·4	35·31

It is very well known that to get a 4 in. flame from gases of different qualities, more gas must be supplied in one case than in another, the lower the illuminating power of the gas the greater the quantity necessary to give a 4 in. flame. While working with the duration test, it occurred to me that a 4 in. flame might be of an uniform illuminating power, whatever the quality of the gas; and that, if this were found to be the case, it would be a simple matter to ascertain what height of flame would be equal in illuminating power to a candle, and that this height of flame might be employed as a standard of comparison, and thus the gas could always be tested by itself. With this idea I made some experiments with the following results :—

Pressure at meter in inches.	Pressure at burner in inches.	Duration of 1·0 cubic feet with 4 inch flame in candles.	Illuminating power of 4 inch flame in candles.
1·4	1·1	65.6	2·58
1·4	0·8	82·5	2·58
1·4	1·3	57·1	2·25
1·7	1·2	78·0	2·58
1·7	1·6	52·5	2·09
1·5	0·5	70·8	2·58

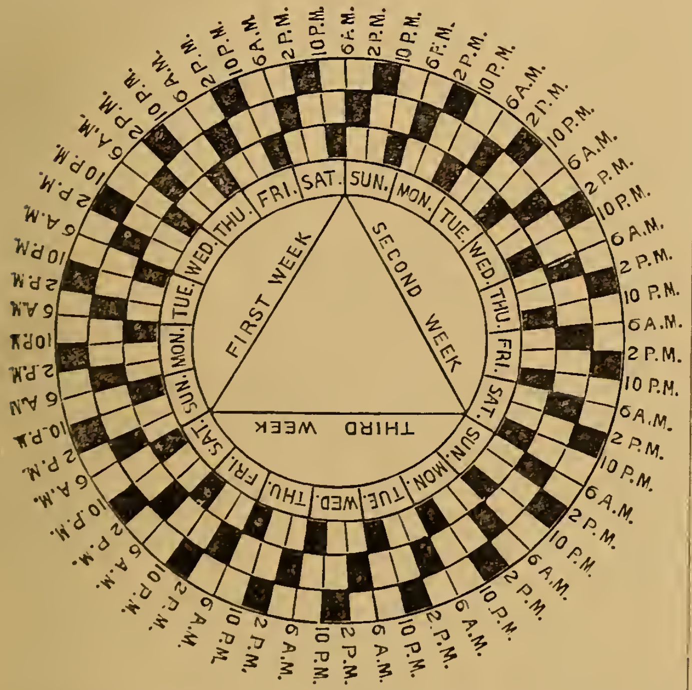
I may state that these experiments are not sufficiently verified to be put forward with confidence. You will observe that there is a perfect uniformity in the illuminating power of the gas within the range of from 65 to 82 minutes duration; at 57 minutes the illuminating power has fallen ·25, and at 52 minutes it has fallen 49.

From these observations on the candle and durability tests I would make the following deductions. First, the condition of the supply of the gas to the burner, and the rate at which the gas is burned in making the candle test are great sources of error; second, the duration test not being subject to these is much more reliable; third, that standard height of flames as a substitute for candles with which to compare the gas may be fixed within certain limits; or that tables of carefully made experiments might be collected to fix with almost absolute certainty, the illuminating power of the gas of a given duration with a 4 in. or other standard flame. This would not only simplify the illuminating power test but would give it a reliability which is at present a desideratum.

During the past year, the question of Sabbath labour in gas works has been put prominently forward by a committee of managers in London, who issued a circular, and addressed copies to 400 engineers and managers of gas works. Of these 154 were returned filled up. The replies to the questions contained in this circular disclose a very general concern on the part of managers on this important subject, which is very hopeful, and should encourage the committee to proceed in their self-imposed task. The right settlement of this question will be cause for joy and thankfulness to thousands. It is an admitted truth that not only is the Sabbath or seventh portion of time divinely appointed as a day of rest from toil, but it is also a human necessity. I may here say that I look upon Sabbath labour in a gas works as to a certain extent necessary under present circumstances. What I regard as desirable is not that no work shall be done from 12 p.m. on Saturday till 12 p.m. on Sabbath, but that men shall not be so overworked as to unfit them, by physical exhaustion, for engaging in the religious service of the Sabbath, and that they shall also have a portion of every Sabbath in their own right, and not as a boon which the manager may withdraw at pleasure, so that they may, if they so choose, receive religious instruction in the house of God upon that day. "The Sabbath was made for man and not man for the Sabbath;" and may we not abide by the spirit, though in present circumstances we cannot adhere to the letter of the command? This, I regard as the inalienable right of every human being, and yet gas companies go on ignoring the fact systematically and universally, as if it were a matter which might be dealt with to suit circumstances. It is without doubt a matter of wrong which circumstances and usage have authorised, and which the stokers have not the power, nor, it may be, the will, to redress. But this is one of the fruits of the system, and for which the managers are undoubtedly responsible. I cannot go into these questions in an address like this, but must deal cursorily with the whole subject. As a rule, gas works are not provided with sufficient gasholder accommodation to enable them to dispense to any appreciable extent with Sabbath labour in the depth of winter. Their stock of gas is exhausted on Saturday night, and Monday is devoted to scarfing retorts, so that on Sabbath the stock must be made up, or rather let me say, is made up. There are no doubt certain gas works which have special facilities for lessening Sabbath labour, and whose managers avail themselves of these facilities to the full—all praise to them—but it is to be feared that the majority of managers are indifferent on this point, or regard it as a necessity that things should remain as they are. As the committee can have no power to remedy or remove these hindrances in their way, I can only see one method of overcoming the difficulty that would be satisfactory or permanent; and that is, the adoption of eight hours' shifts, or three squads of men for the twenty-four hours' work. If this were done, the men would have the ordinary amount of labour, viz., fifty-six hours per week, or seven days of eight hours each, corresponding with six days of ten hours each, less the Saturday half holiday, equal to 57 hours. Thus each man would have sixteen hours for rest and sleep out of the twenty-four, and on every third week, by a proper arrangement, each squad would have the Saturday half holiday and Sabbath free for recreation, rest, and religious improvement.

In explanation of how the eight hours' system may be wrought, I would call your attention to the accompanying diagram, in which the three rings represent the employment of three squads of men. The radial spaces into which these rings are divided represent eight hours each, those coloured indicating work, those blank, rest. These radial spaces are collected into groups of three, representing days, which again are gathered into sevens, for weeks, there being three weeks in the circle, shown by the three sides of the triangle.

The day is divided into three shifts, as marked in the diagram, the first extending from 6 a.m. till 2 p.m., the second from 2 till 10 p.m., and the third from 10 p.m. till 6 a.m., and the three squads take a week of each of these shifts alternately, so that they are at work on the same shift every third week. This allows them a portion of every Sabbath in their own right. On one Sabbath they have from 6 a.m. till 2 p.m. for rest, on another from 2 till 10 p.m., and on the third the whole day, besides the Saturday afternoon and night. For instance, following the diagram, one squad begins the first week on Sabbath by working from 6 a.m. till 2 p.m., the remainder of the day and the night, till 6 a.m. on Monday, being their own. This continues all through the week. On the following Saturday they work till 2 p.m. as usual, but then they rest till 10 p.m. on Sabbath, being thus allowed the whole of Saturday afternoon and night, and all Sabbath till 10 o'clock at night, when they begin again, working till 6 a.m. on Monday, rest during the day, and return at 10 p.m. This continues all through the second week, at the close of which, instead of their regular sixteen hours' rest they have only eight. Leaving work at 6 a.m. on Sabbath, they return at 2, and work till 10 p.m., when they again leave to return at 2 p.m. on Monday. This continues throughout the third week, till when on Saturday they leave at 10 p.m., they have again only eight hours' rest, returning at 6 a.m. on Sabbath, and working the fourth week the same as the first, and so on, in regular rotation.



In this manner the three squads take each of the three shifts alternately, and the regular routine is eight hours labour and sixteen hours rest out of the twenty-four; whilst when changing at the end of the week, once out of three changes, they have thirty-two hours rest consecutively, yet, at each of the other two changes, they have only eight hours, which is equal to three intervals of sixteen hours each, and never have they more than eight hours consecutive labour.

If this arrangement were resolved upon, there would be no difficulty in the way of its adoption; one-third could be taken off the wages, say about Midsummer, and they would very soon adjust themselves as supply and demand always do. Thus a great evil would be redressed, the righteous claims of God and our fellow-men would be met, and, I doubt not, that within twelve months afterwards we should be disposed to wonder that the present state of things had been submitted to so long.

Gentlemen, the subjects which were written down in my notes to be considered in this address are not yet exhausted. These were the progress of the use of machinery in retort house work; the process of carburetting common air as a substitute for coal gas, a process which is every now and again being protected by patent, as if it had never before been heard of; also, a question which was once propounded in this Association, but not answered, viz., "How far is it economical to convey gas in pipes?" These subjects I could not overtake, for, having got thus far, I found that the time allotted me was exceeded.

Before closing, allow me to thank you for the honour you have done me in electing me to the chair of this Association for the past year. I was conscious, from the first, of my inability to do justice to this position, but it was hard to think meanly of myself after your unanimous vote of confidence, and being also assured from past experience of the gentlemanly consideration which I should receive, I accepted the appointment, and have given my best attention to its duties, and can now say, in closing, that I have done what I could.

INSTITUTION OF MECHANICAL ENGINEERS.

ON THE MODE OF WORKING COAL AND THE MECHANICAL APPLIANCES IN THE MIDLAND COAL FIELDS.

By Mr. GEORGE FOWLER.

The author remarked in commencing that one of the principle advantages, of the practice of holding the annual meeting of the institution in different localities was the opportunities which it afforded for the examination of the engineering features of the district, and particularly those in which the same end was accomplished by very different means. The last meeting was held in the northern coalfield, and much was seen of the modes of work there practised. The initial problem in all coal mining was the mode of dealing with the coal of the different strata which overlaid the seams and which imposed a statical pressure upon the new wrought seam in the ratio of its depth from the surface; this pressure being—roughly speaking—equal to about 1lb. per square inch for each foot of such depth. There were two principles upon which this question could be dealt with, which when applied in practice might have very numerous modifications. In the early days of coal mining there did not appear to have been any intercourse between different mining districts, and it was somewhat remarkable, that whilst in some places the leading idea in the most ancient workings appeared to have been to work the coal in galleries and to support these by leaving pillars on either side of them, in many others the idea was to remove the coal entirely and to secure the necessary openings or working places along the edges of the solid seam by taking advantage of the resistance which the overlying rocks opposed to the vertical fracture in shearing. In some localities, therefore, methods of pillar work appeared to be indigenous, while in others the practice had always been to remove the whole of the coal at one operation, or, as it was commonly called, to work it "long-wall." This was the method of coal mining practised in the midland coal field, and the following is a brief description of the principles upon which it was based. In the actual working of a "long-wall" mine the first operation was to drive headways in the solid coal. When these had attained a sufficient length, working places or stalls were started from the side of one of these, and the coal was removed in a series of slices parallel to the headway course. To support the roof of the working-places timber was set, and a pack wall of loose stones was built up at regular intervals. As the faces advanced the timber was withdrawn and the roof settled down—often without fracture—upon the packs. The roadways for the conveyance of the coal were carried at intervals of 20, 30, or 40 yards between pairs of pack walls, and as the roof settled down and squeezed everything tight, the requisite height for the roadway was maintained by ripping or cutting up into the roof. The roadways, therefore, of a "long-wall" coal mine were carried through the goaf or area where the coal had been wrought practically in the rock or other roof of the coal seam. As regarded the application of power for the underground haulage of coal, it seemed improbable that direct steam traction would ever be used except in a case where there was an arched roadway moderately level, and which could be provided with a distinct ventilation, a combination of circumstances that was not likely to occur often in practice. Attention might, therefore, be confined to stationary engines, driving ropes, or chains. Having referred to the method of hauling by "main tail" ropes, the author proceeded to consider the mechanical aspects of the question, and remarked that in arranging any general system of underground haulage it was necessary to carry main roadways not merely on a level course, but with a rise or dip, or, indeed, in any direction which might be dictated by the position of the coal to be worked, in reference to the winding shafts. The average frictional resistance of wagon in collieries was given by the author as being one-fiftieth of their weight, and it was stated that a falling gradient of 1 in 30 was sufficiently steep to enable full wagons when descending to overcome their own friction and haul up a train of empty wagons also. The author's remarks pointed to the conclusion that the haulage of trains of wagons in collieries was less advantageous in many respects than the practice of attaching the wagons singly to an endless chain at intervals of 20 yards or so. The endless chain would be driven by clip drums, and by this plan the wagons themselves would form rolling supports for the chain, and carry it without much additional friction. An application of this system in a mine in the neighbourhood of Nottingham was described by the author, the chain in this case being merely allowed to rest in a kind of hook on the side of each wagon to be moved. The tendency to rust caused by this side attachment, was stated to be counteracted by the tension on the rope, and it was pointed out that in this system the undulations of the road produced no effect so long as the series of wagons was continuous.

Proceeding to consider the lifting of the coal, the author next pointed out that although it is possible to balance accurately the weight of the ropes, tubs, &c., yet the application of steam power to the raising of coal is not favourable to the realisation of a high useful effect on account of the great weights which have to be brought into rapid motion, and subsequently into a state of rest. In deep shafts the weight of the ropes exceeds the net loads, and it is usual to balance them either by the use of a special drum and balance chain, or by coiling them on conical drums of such pitch that the moments of load with empty cages are at every portion of the engine approximately the same. The actual working of an engine consists therefore of a rapid series of motions in opposite directions. In raising a large tonnage of coal each journey of the cages is effected in less than a minute, and each time it is necessary to put the machinery in motion and stop it within that space of time. Three examples were given by the author of different methods of working. Engine No. 1 was stated to be a vertical high-pressure engine with 40in. cylinder and 5ft. stroke, fitted with 12ft. flat rope drum and small balance drum, the action of the balance being to assist the engine until the cages pass, and to absorb power during the remainder of the run. Engines No. 2 are a pair of horizontal high-pressure engines with 36in. cylinders and 6ft. stroke fitted with round rope conical drums, the cone increasing from 20ft. to 30ft. in diameter. Engines No. 3 are a pair of horizontal engines of the same dimensions as No. 2, but with 14ft. wrought-iron flat rope drums without counterbalance. In the case of engine No. 1 the engine man works with the throttle valve open, "hands" the engine fairly started, and then throws the valve gear into action, while at the end of the run he detaches the valve gear and meets the piston with steam on its opposite side. In No. 2 the engine-man also works with an open throttle and regulates the engine by the link motion reversing it at the end of the run; a steam brake being provided for use in case of need. In engine No. 3 the steam and exhaust valves are all worked by link motion and the engine is worked in full gear; the throttle valve being gradually closed towards the end of the run so that a partial vacuum is framed behind the piston, the engine remaining in forward gear.

In the cases above mentioned the loads are drawn from depths of 220, 470, and 415 yards in 30, 45, and 45 seconds respectively, the main speed of the cages being thus 22, 27, and 27ft. per second; but as about one-half of the revolutions are either accelerating or diminishing the velocity, the maximum speeds may be taken at 27, 36, and 36ft. per second. The weight in motion may be estimated as follows:—

	No. 1.	No. 2.	No. 3.
	tons	tons	tons
Flywheel and drums..	15	45	12
Ropes..............	4	6	7
Cages, coal, and tubs..	6	4	8
Pulleys	2	6	3
	27	61	30

Some of the parts move faster, and others slower than the coal, but the mean speed of the whole may be taken as equal to that of the latter. Thus the power expended in putting the masses into motion at the velocities named will be:—

	No. 1.	No. 2.	No. 3.
No of foot-pounds of work required	689,472	2,732,800	1,344,000
Time during which the above power has to be developed	½ min.	¾ min.	¾ min.
Equivalent effective horse power to be developed by engine......	42 H.P.	110 H.P.	54 H.P.

The author then directed attention to the different modes in which the "work" accumulated in the moving mass was disposed of during the latter part of the "run" in the three cases under consideration, engine No. 2 pumping steam (drawn from a long exhaust pipe) back into the boiler. The author further pointed out that if the engine instead of having to develop at the commencement of each run a power greatly in excess of the average, had uniform or nearly uniform work to do throughout each lift, a much smaller engine could be used and there would be a saving of engine and boiler room effected. The question of economy of fuel the author regarded as being a secondary one in such. To attain the desired end of giving the engine approximately uniform work to do, the author recommended the employment of conical drums having their contour lines so far modified from those usually adopted that during the first two or three strokes of each run scarcely any lifting would be done, almost the whole power of the engine being employed in putting the machinery into motion. The contour moreover would be such that during the middle strokes the engine will lift the load and overcome the friction, and that in the last two or three strokes the leverage of the load will be so much increased, that the momentum will be usefully expended in assisting the engine to complete the lift. In the apparatus which the author described in connexion with this drum (which is in use in a colliery in the neighbourhood) it was desirous for the purposes of ventilation to reduce the area of the cages, to avoid impeding the ventilation. So they were made with four platforms, each holding one ton of coal. To save time in emptying and loading, these platforms or decks were furnished with two points of unloading and loading, so that they could be all loaded and emptied with one change in the position of the cages. The time occupied is not more than twenty seconds, and the engine can raise 180 wagons of coal per hour.

Mr. U. B. Vidal, of Philadelphia, proposes to provide the street cars with strong skirts or nets, supported on frames to extend from the flooring down to or near the ground. Tee object of tne improvement is to save persons who fall from being run over by the car. The frame which supports the net is to be elastic, vertically, so as to yield when any portion touches the ground.

A NEW MOUNTAIN LOCOMOTIVE.

A very interesting trial was made on the 11th ult., in the "cabbage garden" at Hatcham of a new locomotive, designed by Mr. Robert Fairlie for the Iquique Railway in Peru. The "Tarapaca" is of the now well-known double engine type. It has four cylinders, 15 inches in diameter and with a stroke of 20 inches, and each pair of cylinders drives a group of six wheels, 3ft. 6in. in diameter. Each group of wheels has its cylinders and machinery complete, and forms a bogie, on which one end of the boiler is supported, and turns freely on a vertical axis. The boiler is 30ft. 6in. in length, cylindrical for 10ft. 6in. at each end, and the central space is reserved for the fire-box. This is divided into two by a water partition, which widens from below upwards. Opposite the water partition, at each end of the fire-box, is the usual tube plate for the tubes that carry the products of combustion from each fire through the cylindrical portions of the boiler to the respective smoke-boxes, which are of the ordinary kind. There are thus two fire-boxes, two sets of tubes, two smoke-boxes, and two chimneys, for a common water and steam space, and when the compound boiler is mounted on its bogies both ends are precisely alike, and the engine can run in either direction with equal facility, so that no turn-tables are required for it.

By this arrangement, without increasing the magnitude of the parts. Mr. Fairlie has succeeded in obtaining a very economical and rapid steam generator. It is believed that the plan will be found to work much better than two separate boilers of the same size on account of the advantage derived from the water partition, and from the absence of the two back plates of the fire-box shell which separate boilers require.

The engine bogies are maintained in position by a cradle-frame, which connects the two together by their centres, and forms with them the body of the locomotive. On this the boiler simply rests, with no other function than to provide steam for the cylinders, and, is free to expand or contract in any direction. The steam pipe is carried down at each end in the axis of rotation, so as to be itself stationary; and the exhaust pipe is rendered freely moveable by ball and socket joints.

The Tarapaca has 1,500ft. of tube-heating surface, 125ft. of fire-box surface, and 21ft. of fire-grate area. The tanks carry 2,200 gallons of water, and the bunkers two tons of coal. The engine has a tractive force at the rails of 9½ tons, which would enable it to draw a train load of 2,000 tons at 12 miles an hour on the level. The Iquique line has very steep gradients, one of which is one in 26 for 11 miles, and up this the engine is calculated to draw 150 tons of train load at 11 miles an hour.

The railway in Mr. Fairlie's works at Hatcham consists of two parallel portions, about 200ft. long and 100ft. apart, connected at each end by semicircular portions, which are consequently of 50ft. radius. The Tarapaca ran easily and rapidly round the irregular ellipse thus formed, and its movement was without any perceptible oscillation. The sharpest curves in the Iquique Railway have a radius of 300ft.

FATAL BOILER EXPLOSION.

A fearful boiler explosion, resulting in the death of three persons and the serious injury of six others, occurred on the 13th ult. at the brick works of Mr. J. W. Stableford, at Coalville, about 16 miles from Leicester. It seems that at the works in question, which anjoins the Midland Railway, there is an upright boiler of five horse-power, which drives an engine used in the drawing up of tubs of clay from the pit and the grinding of clay. The boiler was almost new, having only been in use six weeks, and undergone a thorough testing up to 100lb. pressure. It was, however, intended not to be worked above 50lb. pressure, and was likewise provided with a safety plug in the event of its becoming short of water.

Shortly after one one o'clock on the 13th ult. the men engaged in the brick-yard resumed their work after dinner, when the stoker, a boy named Thomas Underwood, 15 years old, went into the engine shed for the purpose of starting the engine. It had scarcely been set in motion when the boiler, which was in the open, exploded with a terrific report, which was heard many miles off. The noise soon brought a large crowd to the spot, where, after the the steam had cleared off, a sad and sickening sight presented itself. The engine and other sheds were entirely demolished, and among the ruins were found two dead bodies and seven other workmen seriously injured. William Davies, 10 years, and Joseph Thomas Armstead were killed on the spot, and their bodies presented a sickening sight, being frightfully mutilated and their intestines protruding. The others injured were Frank Underwood, five years, Thomas Garner, 22, Thomas Hardy, 30, Frank Armstead, 12, Alfred Orton, 13, Phillip Greasley, 35, Thomas Underwood, 15, and Henry Brookes, 30. Drs. Toone, Thomas, Halchett, and Johnson were soon on the spot and attended the injured, who were as speedily as possible removed to their own homes. Frank Underwood, who had been to take his brother's dinner was so seriously scalded and burnt that he died about six o'clock on the next morning. Frank Armstead, brother of one of the killed, and Alfred Orton are seriously injured, the latter having his left knee shattered and back scalded very badly. They are not expected to recover. Thomas Underwood, who was close to the boiler, and the youth who started the engine, is but slightly hurt. Garner has a severe cut across the forehead; Hardy, the brickmaker, in the back of the neck; and Groasley is very badly bruised. Brookes, who had no business on the premises, but was loitering about, was but slightly injured, and Isaac Cooper, the foreman, who was blown on to the railway, miraculously escaped almost unhurt.

So great was the force of the explosion that portions of the boiler were thrown a considerable distance. One large piece was carried into the parish of Whitwick, over 150 yards away, where, falling on to the roof of a house, occupied by William Gibbs, it broke through the roof and fell into the chamber.

ON THERMODYNAMICS.

The following letter has been addressed by Professor Rankine to the Editors of the "Philosophical Magazine and Journal:"—

GENTLEMEN,—If I rightly understand the paper of the Rev. J. M. Heath, published in the "Philosophical Magazine" for July, 1870, p. 51, he lays down a principle which may be virtually expressed by saying that the work done by a force in overcoming attractions or repulsions cannot take effect in producing heat—that is, in accelerating molecular motions. That principle is perfectly correct, and is an obvious consequence of the laws of motion; and every one who knows those laws must agree with Mr. Meath when he states it. But from the remarks with which his statement is accompanied he seems not to be aware that this very principle has been most carefully kept in view by every author of original researches in thermodynamics, and by every writer on the subject who has understood those researches. In fact, the problem which is solved by the general equation of thermodynamics may be stated as follows:—A certain quantity of work being done by the action of external forces on a body in a certain way, to distinguish that quantity of work into two parts, one of which is expended in overcoming molecular attractions and repulsions, and the other in accelerating molecular motions.

A system of particles contained within a vessel and in a state of rest, being kept *in æquilibrio* by their mutual attractions and repulsions, exerts a pressure or a tension against the internal surface of that vessel according as repulsions or attractions predominate; and work done in altering the capacity or the figure of the vessel does not produce heat, but only stored-up energy, like that possessed by a bent spring.

A system of particles confined within a vessel, and not sensibly attracting or repelling each other, but in a state of motion, exerts outward pressure against the internal surface of that vessel through the reactions of the particles that tend to escape, but are prevented by the vessel from doing so; and work done in diminishing the capacity of this vessel wholly takes effect in accelerating the motions of the confined particles—that is, in the language of thermodynamics, producing heat.

The condition of actual bodies is compounded of those two; and it is by means of an equation deduced from what has been called the "Second Law" of thermodynamics that the force exerted by a substance against the internal surface of a vessel containing it (in other words, the elastic force of the substance) is distinguished into two components, due respectively to molecular attractions and repulsions, and to the reactions of moving particles (of the nature of centrifugal force). It is the latter component of the force only that is taken into account in calculating how much heat is produced by a given alteration of the dimensions or figure of the containing vessel.

It has been proved by experiment that very nearly the whole of the work done in compressing a gas takes effect in producing heat; and hence it has been concluded that the elasticity of gases is almost wholly due to the motion of their particles, the component due to attractions and repulsions being small in comparison.

The detailed exposition of the principles to which I have briefly referred, and the comparison of their results with those of experiment, have been made so often, by so many authors, and in so many ways, that it would be a waste of time and space for me to explain them further here; and I shall, therefore, in conclusion, merely refer to Professor Tait's work on Thermo-dynamics as the best source of information regarding the history and present condition of that science; for he gives a summary, in very moderate compass, of the different methods of demonstration followed by the various original authors. In most of the popular writings on the subject, the second law of thermodynamics, together with its proofs and consequences, is omitted, as requiring too much mental exertion for its comprehension.—I am, gentlemen, your most obedient servant,

Glasgow, July 5th, 1870. W. J. MACQUORN RANKINE.

A SOLUTION of tanning has been used in the treatment of cotton fabrics, as hides are in the manufacture of leather. The cotton thereby acquires greater strength, and better resists moisture and disintegrating effects. No attempt is made to explain the chemical reaction which produces this important change, but it believed that the change cannot be great, since it has escaped the notice of practical tanners.

THE PRUSSIAN AND FRENCH NAVIES.

The following information respecting the navies of the two countries now engaged in such a terrific struggle will, we think be interesting to to our readers, although, up to the present time, but little appears to to have been accomplished in naval warfare:—

"During the last few years Prussia has done her best to strengthen her power in the Baltic and North Seas. On both these seas she now has an important and an uninterrupted sea coast. On the Baltic Prussia has three ports——Dantsic, on the extreme east; Stralsund, midway between Memel and Holstein; and Kiel, the most important, which is established in a fine bay in Holstein. Of these three ports Kiel is so important that Russia has been represented as sore on the subject. The most superficial glance on the map will show the importance of Kiel to the Prussians. When complete, it is so well situated, both geographically and locally, as to show that it may easily be the Cherbourg of the Baltic. It is said that when it is finished the Baltic will be merely a Prussian lake, and that Prussia will then, without any difficulty, not only be able to close the entrance to foreign fleets, but will possess the most complete power over Copenhagen. The port of Jade, on the North Sea, has been established and extended with such spirit, that already a million and a half sterling has been spent upon it. Its situation is most tempting, for it is the first point on the North Sea coast which a hostile fleet could approach. But in ships as well as in establishments Prussia has been using great energy; so much so that at this moment she has seven ironclads at least either completed or being built, of which six are now complete. One of these, the *Konig Wilhelm*, is one of the finest in the world. It was built originally for the Turkish navy, but was bought by the Prussians, after it had been offered to this country and refused. Her other ironclads are the *Freidrich Karl* and *Kron Prinz*, which are broadside vessels, and the *Arminius* and *Adalbert*, which are turret-ships. Besides these there are 33 wooden vessels of various sizes.

The French navy has the advantage of age, tradition, and size on its size. The ports of Prussia are important, perhaps more so than those of France; but the German ships are not numerous enough to protect her merchandise efficiently. On the other hand, if the ports of France are not so important as those of Prussia, her navy is far stronger, and her ships far more numerous.

The war fleet of France consists at the present moment of about 60 iron clads, including floating batteries. Large, however, in size as is this war fleet, its strength is not in proportion to its size. Compared with the Prussian navy it can only oppose satisfactorily one ship to the *König Wilhelm*. The *Rochambeau*, which the French Government bought from America in 1867, is a most powerful vessel. It is a ram, but carries its guns broadside, and has a burden of 5,090 tons. Four very powerful vessels, at least, the French navy can oppose to the two turret ships of the Prussians—the *Taureau*, the *Bélier*, the *Cerbère*, and the *Boule Dogue*. These four are steam rams, and have a speed of about 14 knots each. They each carry one gun of 20 tons, and each is covered with a cylindrical ball-proof dome. The remaining 54 ironclads may be divided into nine classes. First there are the *Magenta* and *Solferino*, which are large but are old-fashioned; then the *Gloire*, *Invincible*, and *Normandie* are slightly smaller but are not much better than our *Warrior*. The *Couronne* then stands alone, being better plated and protected than those we have mentioned, but in ordnance being on a par with them. Then come the vessels built on one uniform system, to carry 36 guns and 900 horse power. Then the *Belliqueuse* is a remarkable vessel, which stands in a class by itself, and is known to us chiefly in connexion with its recent voyage round the world. It carries 10 60-pounder guns. Then there are two turret vessels, on a modified form, the *St. Jean de Arc* and *Atlanta*, and four vessels which are small in size and unimportant. Those form the sea-going war-fleet of France. Besides these, for the protection of the coasts there are 27 floating batteries and four coastguard vessels, built to carry heavy guns, but having no great speed.

As regards ships, there is no comparison between the French and the Prussian navies, except that, while the French navy includes a large number of bessels of no importance and out of date, every war-ship or iron-clad in the Prussian navy is powerful and important. The ordnance of both navies has, previous to the present year, undergone great modifications. Both Prussia and France have found out that their ordnance was unsatisfactory two years ago. Admiral de la Ronciere in France and Krupp in Germany have given great attention to ordnance, and have introduced great improvements, but though both navies possess guns of great power the ordnance of both is now very incomplete.

But while in ships and ordnance Prussia can compare to a great extent favourably with France, in men there can be no comparison. While the French navy can, in time of war, raise 170,000 men, Prussia has only, at the outside, 4,000 men upon which the Government can rely. Not only are numbers in favour of the French, but the discipline, the traditions, and the skill of both officers and men are in their favour.

CORRESPONDENCE.

(The Editor is not responsible for the opinions expressed by Correspondents.)

COAL SUPPLY AND COLLIERY WASTE.

TO THE EDITOR OF "THE ARTIZAN."

SIR,—So much has been said and written in reference to our coal supply, and so many elaborate statements and statistics have been volunteered with a view to arrive at some sort of estimate touching the probable period of its exhaustion, that the subject would seem to be worn threadbare; yet little or no allusion has been made to the enormous *waste*, which, in almost every instance, may be noticed in our colliery operations; as in the masses of material suffered to accumulate in the pit—frequently the spontaneous source of deplorable consequences—and in the consigning of much valuable mineral to the mound or waste heap. The importance of this matter induces me to send you the following particulars of Homfray's Patent Separator, which is doing such good service at the New British Iron Company's New Hauvre Colliery, Halesam, Worcestershire.

The machinery or apparatus for separating, without the application of water, is represented in longitudinal vertical section by Fig. 1, and in plan by Fig. 2, each letter indicating the same part in both figures.

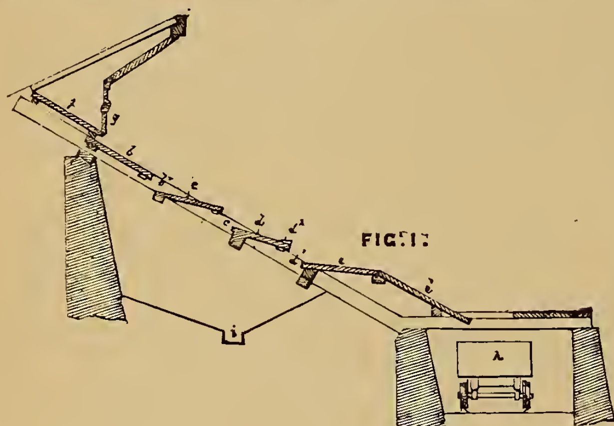


FIG. 1.

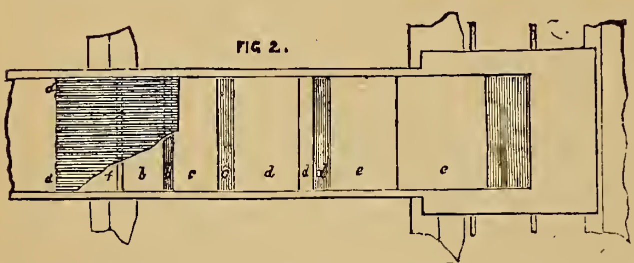


FIG. 2.

It consists of an upper inclined screen or platform *a*, and a series of lower platforms, *b*, *c*, *d*, of wood or iron, or wood covered with iron, separated by horizontal divisions or spaces *b′*, *c′*, *d′*, and forming a step-like figure; the spaces between the platforms being of sufficient width to permits the bats and other refuse to fall through them. Under the upper screen *a*, is a hopper *f*, provided with a door *g*, the step or platform *b* has a greater inclination than the lower platforms. The coal from the pit (when the whole of the get is intended to be operated upon) is tipped on to the screen *a*, the larger coal passing down it into a wagon or heap. The small coal passing through the screen *a*, is received in the hopper *f*, and retained by the door *g*, on opening which, the small coal and refuse dropping a few inches, falls on the platform *b*, from which the coal passes to the platform *c*, and so on to the platforms *d* and *e*; the momentum which the coal acquires, causing it to jump the openings *b′*, *c′*, *d′*; whereas the bat and dirt being denser, and moving with greater friction on the platforms, and, consequently, not acquiring sufficient momentum to jump the spaces, fall through at *b′*, *c′*, *d′*. As the velocity of the coal increases as it progresses in descent it becomes capable of clearing a wider aperture, hence each of the spaces *c′*, *d′*, is wider than the one above it, so as to permit such larger and flat bats, &c., to fall through them as may be incapable of passing through at *b′*. When it is necessary to further retard the bats, &c., V shaped pieces of wood may be placed transversely on either or any of the platforms, as shewn at *d*2. The screened or separated coal passes down the platform *e* into the wagon *h*. The bats, slack, ironstone or other impurities that fall through the openings *b′*, *c′*, *d′*, are carried by water down an inclined channel and trough *i* and *k*, fig. 3, and further and effectually separated by the washing process. The platforms may be varied in number and inclination, and any one or more of them made to act as screens, to suit the nature of the materials operated upon.

The appliances for separating or screening by water, are represented in longitudinal vertical sections by Figs. 3 and 4.

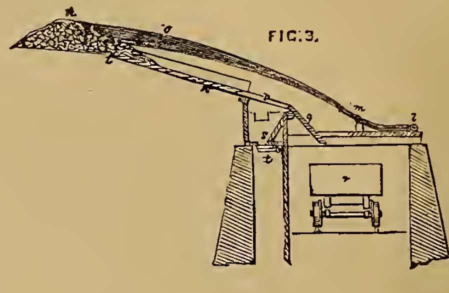


FIG. 3.

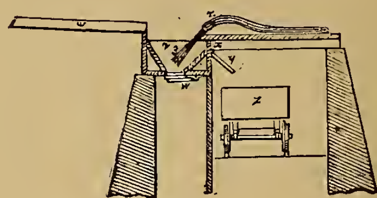


FIG. 4.

1, *k*, is a trough or channel down which the refuse from the screens of the separating apparatus, Figs. 1 and 2, passes to be further separated by water, which is either supplied from a suitable level above the trough or channel or pumped with the required pressure, and conveyed by the flexible hose *l*, to the nozzle or jet *m*, and is delivered with considerable force upon the refuse matter *n*. The mechanical force of the jet of water o, combined with its solvent power, effects a very complete separation of the coal from adhering pieces of bat or clay. The slack, bats and water descending on the lower part *k* of the trough are received on the screen *p* the larger bats passing over the said screen *p* down the incline *q* into the wagon *r*, while the water and small pieces of coal and bats pass through the screen *p* into the box *s*. The hose *l* and jet *m* are under the control of the attendant, who guiding the jet o, can keep the screen *p* clear; the box *s* receiving the slack and small bats through the screen *p*, has a trap or valve *t* at its bottom (or side); when the trap *t* is closed, the slack and water flow down the trough or sluice *u*, figure 4, and fall into another box *v*, with a trap *w*, at its bottom side, or end; the traps *t* and *w* of the boxes *s* and *v*, are opened from time to time, to let out any heavy particles that may have collected theroin; the coal and water descending the channel or sluice *u* into the box *v*, are in such a state of agitation that the coal is brought to the surface and passes over the side *x*, figure 4, down the incline *y* into the wagon *z*. In its passage from the box *v* to the wagon *z*, it may, if necessary, be further screened or washed by similar arrangements. In front and on the top of the box *v*, is another hydraulic hose and Nozzle 2 by which a jet of water 3 is delivered with considerable pressure, whereby the agitation of the water and coal in the box *v* is augmented, and the contents of the said box *v*, constantly stirred up.

Only such material as would otherwise go to the waste heap, or remain below, is in this case operated upon, and the amount of coal and slack saved is enormous. No accumulation goes on in the pits, and it pays well to raise all to the surface. As many as 240 tubs (14 cwt. each), of this waste alone have been operated upon at this colliery in one day, and, that, with a considerably less number of hands employed on the pit bank.—Yours respectfully,

Birmingham, 31st August, 1870. GEO. RYLAND.

WALTON BRIDGE.—The Committee of the Metropolitan Board of Works and the Corporation of the City of London, called the joint committee, appointed under the provisions of the Act, 1869, for releasing the Thames bridges from toll, have by their efforts already opened the bridge at Kingston, and on the 4th ult., in the midst of general rejoicing on the part of the inhabitants of Walton, in Surrey, on the south, and Shepperton, in Middlesex, on the north side of the Thames, Walton Bridge was thrown open, and declared to be henceforth free of toll. The members of the joint committee, on arrival at Sheppertou, were received by the Rev. C. J. M'Cowan, vicar of Walton, Mr. E. Wilson, J.P., and other local residents, and proceeded to the bridge, where the key of the gate was handed over to Sir J. Thwaites by Mr. Woodbridge, acting as solicitor of Mr. Allen, late proprietor. The vicar read an address, to which Sir John Thwaites replied. The gates were then removed, amid the cheers of the people.

NOTES AND NOVELTIES.

MISCELLANEOUS.

AUSTRALIAN DISCOVERY.—Some fine country is reported to have been discovered to the north-west of Mount Margaret, in South Australia. There are two rivers abounding with fish, and a large extent of first-class pasture land, which is well watered.

THE new iron landing-pier in the Royal Arsenal is about to be connected with the South Eastern Railway, and workmen are at work laying down the rails.

SOME petroleum springs are said to have been discovered in France, near the Forest of Haguenau.

THE Boston Belting Company have recently manufactured two large india-rubber belts to be used in a grain elevator in Canada. One of them is 250ft. long, 28 in. wide, and weighs 1340 lb., containing 2920 square feet of cotton duck; the other is 532 ft. long, and 22 in. wide, and weighs 2138 lb., containing 3907 square feet of duck.

NAVAL ENGINEERING.

THE 35-TON GUN.—The large gun now in course of manufacture at the Royal Gun Factories, Woolwich, is expected to prove the most powerful piece of ordnance ever produced, and to settle definitely the long and hitherto even contest between guns and armour. It will weigh 35 tons, and will hurl a projectile of 550lbs. with a charge of 100lbs. of powder, thereby imparting an initial velocity which will enable it to pierce an armour plate of iron 15in. in thickness, beyond which no ship meant to float can surely go. The barrel is of steel, strengthened at the breech by a strong iron jacket, and the calibre of the bore is about 11½in., but this point has not been definitely settled.

A NEW ARMOUR CLAD.—Orders have been forwarded to Chatham dockyard, from the Admiralty, directing another large iron vessel of war, the name of which will be the *Raleigh*, to be immediately commenced. The *Raleigh* is to be constructed from Mr. Reed's design's, the drawing showing her to be a broadside vessel of large dimensions, having a burthen of between 4000 and 5000 tons, with engines of 1000 horse power. The new vessel is to have her hull, below the water, encased in wood, and will be similar in this respect to the *Inconstant*, attached to the Channel squadron. The *Raleigh* will be of the broadside type, and is designed to carry a heavy armament of twenty-seven guns, of large calibre, in her maindeck central battery and on her weather deck.

MILITARY ENGINEERING.

CONVERTED ENFIELD RIFLES.—A new method of converting the Enfield muzzle-loading rifle into a breechloader was tried in the Royal Arsenal, Woolwich, on the 16th ult. It is the invention of Mr. Restall, of Birmingham. The breech arrangement consists of a steel block, which is moved horizontally to the right by the cocking of the rifle, and when the cartridge is inserted, the pull of the trigger closes the breech and fires the rifle simultaneously. The merits claimed for this invention are rapidity, simpilcity, and cheapness. In the hands of a rifleman who had not seen the weapon before, it made 27 rounds in two minutes, with a score of 68 points. The Enfields, it is stated, can be converted into breechloaders on this principle at a cost of 5s. each.

LAUNCHES.

THE *Astarte*, the first of Messrs. Donaldson Brothers new line of screw steamers from the Clyde to the Brazils and River Plate, was launched on the 11th ult. from the Stobcross building yard of Messrs. Barclay, Curle and Co. The *Astarte* is about 1,350 tons register, and is to be fitted by the builders with engines on the compound principle. Her cabins and other arrangements are specially adapted for the trade, and for the comfort and convenience of passengers. The ceremony of naming was gracefully performed by Miss Hennessy, of Swansea. The builders have a sister steamer, to be named the *Marina*, in an advanced state of progress for this line, which the *Astarte* is to open about, we understand, the middle of October.

LAUNCH OF A STEAMER FOR A GLASGOW FIRM AT KIRKCALDY.—A magnificent iron screw steamer was launched on the 11th ult., from Abden shipbuilding yard near Kirkcaldy. The steamer, which is the property of the Glasgow and South American Steam Shipping Company, was named the *Andes*; and her dimensions are:—Length between perpendiculars, 265ft.; over all, 282ft. Breadth of beam, 32ft. 3in.; depth of hold, 17ft. She is 1,355 tons according to builder's measurement, and 1,584 tons gross. She is fitted up with engines of 160 nominal horse power; and accommodation is provided for 20 first, and 170 third-class passengers. She is classed 100 A (first-class) at Lloyd's. Another large steamer, to be named the *Alps*, is being built by Mr. Kay for the same company.

ON the 17th ult. Messrs. John Elder and Co. launched from their shipbuilding yard, at Fairfield, Govan, an iron screw steam ship of 1,975 tons B.M., and 350 horse power nominal, and of the following dimensions:—Length between perpendiculars, 280 ft., breadth, 38 ft., depth moulded, 24 ft. 3 in. As she left the ways she was christened the *Atacama*, by Miss Just, daughter of William Just, Esq., managing director of the Pacific Steam Navigation Company of Liverpool. The *Atacama* has been built to the order of the Pacific Steam Navigation Company, and is intended for their passenger and cargo carrying service on the West Coast of South America. The builders have five steam ships on the stocks for the same owners, viz., the *Coquimbo*, sister ship to the *Atacama*, and the *John Elder*, *Cuzco*, *Chimborazo*, and *Aconcagua*, each of 3,200 tons B.M., and 500 horse power nominal.

SHIPBUILDING.

THE City of Dublin Steam Packet Company has added another vessel to its already large fleet in the paddle steamer *Longford*, built by Messrs. Laird Brothers, of Birkenhead. The *Longford* is 250 ft. long by 27 ft. beam, and 16 ft. deep. She is fitted with engines of 300 horse power, having inclined oscillating cylinders before and abaft the shaft, and two boilers placed abaft the engines. On her trial trip the *Longford* attained a mean speed of 14¾ knots per hour, the engines making 27 to 28 revolutions per minute, with a pressure of steam of 25 lb. per square inch.

AN order has been given to convert into an iron clad ship the *Robust*, which has for twelve years been on the stocks at Devonport about two-thirds built.

RAILWAYS.

THE MONT CENIS RAILWAY.—It is stated to be in contemplation to discontinue the Mont Cenis Railway service during the winter, when it involves loss, and to run sledges in its place.

SOME of the principal planters of Bon Jardin are promoting a scheme for a narrow gauge extension of the Bahia and San Francisco Railroad, about sixteen miles in length, from Alagoinhas into that district, which, if carried out, could not fail to be a valuable feeder to the railway.

SLEAFORD RAILWAY.—Mr. Firbank, of Newport, Monmouthshire, who constructed the principal portion of the London end of Midland Extension, has taken the contract for the Great Northern, Sleaford to Bourne, 17 miles in length.

THE Pullman Palace cars have been withdrawn from the American railroads, the habits of the travelling public not permitting their continued use.

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	s.	d.	£	s.	d.
COPPER.						
Best selected, per ton	73	0	0	,,	,,	,,
Tough cake and tile do.	71	0	0	,,	,,	,,
Sheathing and sheets do.	75	0	0	76	0	0
Bolts do.	76	0	0	77	0	0
Bottoms do.	77	0	0	78	0	0
Old (exchange) do.	63	0	0	,,	,,	,,
Burra Burra do.	70	0	0	71	0	0
Wire, per lb.	0	0	10	,,	,,	,,
Tubes do.	0	0	11	,,	,,	,,
BRASS.						
Sheets, per lb.	0	0	8¼	0	0	0
Wire do.	0	0	7¼	,,	,,	,,
Tubes do.	0	0	10	,,	,,	11½
Yellow metal sheath do.	0	0	6½	0	0	7
Sheets do.	0	0	6¾	,,	,,	,,
SPELTER.						
Foreign on the spot, per ton	18	10	0	19	0	0
Do. to arrive	,,	,,	,,	,,	,,	,,
ZINC.						
In sheets, per ton	24	0	0	25	0	0
TIN.						
English blocks, per ton	126	0	0	127	0	0
Do. bars (in barrels) do.	127	0	0	128	0	0
Do. refined do.	130	0	0	,,	,,	,,
Banca do.	128	0	0	130	0	0
Straits do.	128	0	0	,,	,,	,,
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	6	6	1	8	0
IX. do. 1st quality do.	1	12	6	1	13	6
IC. do. 2nd quality do.	1	6	0	1	6	6
IX. do. 2nd quality do.	1	12	0	1	12	6
IC. Coke do.	1	3	0	1	3	6
IX. do. do.	1	9	0	1	9	6
Canada plates, per ton	13	10	0	14	10	0
Do. at works do.	13	0	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	7	6	,,	,,	,,
Do. to arrive do.	7	5	0	,,	,,	,,
Nail rods do.	7	10	0	,,	,,	,,
Stafford in London do.	8	5	0	9	0	0
Bars do. do.	8	0	0	9	0	0
Hoops do. do.	8	15	0	9	0	0
Sheets, single, do.	9	10	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	0
Bars, common, do.	6	10	0	6	15	0
Do. mrch. Tyne or Tees do.	6	10	0	,,	,,	,,
Do. railway, in Wales, do.	7	0	0	7	5	0
Do. Swedish in London do.	9	5	0	9	10	0
To arrive do.	,,	,,	,,	,,	,,	,,
Pig No. 1 in Clyde do.	2	12	0	3	0	,,
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	0
Do. No. 3 and 4 f.o.b. do.	2	6	6	2	7	,,
Railway chairs do.	5	17	0	6	0	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pig in London do.	6	5	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	13	10	0	13	15	0
Do. (hammered) do.	14	5	0	14	10	0
Do. in faggots do.	15	10	0	,,	,,	,,
English spring do.	17	0	0	23	0	0
QUICKSILVER, per bottle	8	8	0	,,	,,	,,
LEAD.						
English pig, common, per ton	19	10	0	20	5	0
Ditto. L.B. do.	20	5	0	,,	,,	,,
Do. W.B. do.	20	10	0	21	0	0
Do. sheet, do.	20	10	0	21	10	0
Do. red lead do.	21	10	0	,,	,,	,,
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	22	10	0	23	0	0
Spanish do.	19	0	0	,,	,,	,,

*At the works 1s to 1s. 6d. per box less.

LIST of APPLICATIONS for LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated July 26th, 1870.

2097 H. A. Bonneville—Canopies
2098 J. Withinshaw—Mills for crushing minerals
2099 C. Gall—Regulating the admission of air to furnaces
2100 W. R. Lake—Parchment paper
2101 W. R. Lake—Solid collodion
2102 A. V. Newton—Railway wheels
2103 J. H. Johnson—Weigh beam for weighing machines
2104 W. H. Harfield—Securing cables
2105 J. Naysmith—Surveying instruments
2106 A. E. Reed—Paper

Dated July 27th, 1870.

2107 J. Piddington—Revolvers
2108 B. F. Weatherdon—Bodies of hats
2109 A. Turner—Thread
2110 W. New—Heating water
2111 P. C. Don—Carbonate of soda
2112 W. R. Lake—Furnace grates
2113 T. and W. B. Kirby and R. Brady—Raising and lowering revolving shutters
2114 E. J. Curtin—Steam gauges
2115 I. L. G. Rice—Inking apparatus for printing presses

Dated July 28th, 1870.

2116 R. A. Gooding—Cork drawer
2117 A. G. Southby—Cooking by gas
2118 J. Pinchbeck—Water tube boilers
2119 W. J. Schlesinger—Nailing carpets
2120 R. Boyle—Ventilators
2121 W. H. Richardson—Stamping measures
2122 E. Vignier—Distilling
2123 J. Grant—Flyers

Dated July 29th, 1870.

2124 T. A. Vyse—Guiding covered wire to be secured upon a fabric or substance in a sewing machine
2125 G. C. Fowler—Fumigating
2126 T. R. Hayes and C. R. Peters—Detecting false receipts, &c.
2127 J. C. Ramsden—Looms
2128 T., G., and A. A. Walker—Furniture castors
2129 J. Craddock and C. F. Richards—Lockets
2130 J. G. Willans—Iron
2131 G. Turton—Lighting fires
2132 H. R. Minns—Securing the doors of safes, &c.

Dated July 30th, 1870.

2133 E. Lawrence—Cutting metals
2134 W. N. Hutchinson—Iron rails of railways
2135 W. E. Gedge—Application of atmospheric power to locomotive and ascension machines
2136 J. Wozniakowski—Feed-water apparatus for steam boilers

Dated August 1st, 1870.

2137 D. R. Dossetor—Axles
2138 C. F. T. Young—Lubricators
2139—B. Picard—Propelling vessels
2140 B. Picard—Navigation
2141 F. A. Paget—Filamentous matter suitable for spinning from sundry plants
2142 G. Schadler—Measuring the human body, &c.
2143 W. Brownlie—Show tablets
2144 E. Otto and N. Wilson—Railway buffer and other springs
2145 W. A. Gibbs Drying apparatus
2146 F. J. Barnby—Turn-buckles
2147 A. V. Newton—Cutting and pulverising stone

Dated August 2nd, 1870.

2148 T. Evans—Buttons
2149 T. Carr—Wheat flour
2150 A. F. Debai—Free-reed musical instruments
2151 J. Dewar—Treatment of certain substances used as food
2152 J. Edwards—Locks
2153 W. R. Lake—Lubricating packing for railway journals
2154 W. R. Lake—Let-off mechanism of looms for weaving
2155 G. F. Greiner and J. F. Hiller—Velocipedes
2156 A. V. Newton—Feeding paper to printing machines
2157 W. Richardson—Condensing carding engines
2158 D. N. Defries—Gas meters
2159 W. R. Lake—Preservation of wood

Dated August 3rd, 1870.

2160 J. Spratt—Preparation of coffee and tea
2161 F. M. Pratt—Tell-tale locks
2162 G. Brown—Preparing iron
2163 E. Fileti—Compasses
2164 H. E. Brown—Carriages
2165 G. H. Pierce—Receptacles for wine or other bottles
2166 W. R. Lake—Sewing machine
2167 W. R. Lake—Refining and ageing liquors
2168 G. Warsop—Steam engines
2169 R. Porter and T. Lane—Horizontal steam boilers

Dated August 4th, 1870.

2170 I. T. Miller—Hammers
2171 W, B. Woodbury—Producing surfaces by the aid of photography
2172 W. R. Lake—Sewing boots
2173 W. R. Lake—Extinguishing fires
2174 L. Sterne and P. Brotherhood—Accumulating hydrostatic pressure
2175 J. C. Young—Securing cupboards
2176 T. Barling—Gas burners
2177 J. A. de Macedo—Obtaining motive power
2178 I. E. Ridges—Funeral or composite carriages
2179 J. Sycamore—Smoky chimneys
2180 W. R. Lake—Knitting machines

Dated August 5th, 1870.

2181 T. Calver and E. Hines—Shanks to buttons
2182 J. Taylor—Cutting the pile of cotton velvet
2183 C. D. Abel—Raising, lowering, and transporting objects
2184 M. Eyth—Steam engines
2185 F. R. A. Glover—Raising anchors
2186 A. Stewart—Railway wrappers

Dated August 9th, 1870.

2187 G. W. Hick—Separating solid substances
2188 W. T. Bury—Axes
2189 W. T. Bury—Shafting picks, &c.
2190 G. Demailly—Paper
2191 J, Johnson—Paints
2192 J. Marsden—Protecting soldiers in battle
2193 R. Edwards—Steam cultivation
2194 S. Leoni—Disinfecting and cooking by heated air
2195 M. Hess—Fastener for leggings

Dated August 8th, 1870.

2196 R. Morton—Cooling and heating liquids
2197 J. E. Lowe—Permanent way relating to iron chairs
2198 J. Nadal—Nozzles for pipes in watering gardens
2199 R. Allen—Flour
2200 J. G. Marshall—Ventilation
2201 W. W. Pilkington—Glass
2202 J. M. A. Lacomme—Exbibiting advertisements

Dated August 9th, 1870.

2203 H. A. Bonneville—Treating minerals and ores
2204 J. A. Keates and J. F. Allen—Metallic alloys
2205 W. Richards—Fire-arms
2206 E. J. Powell—Preserving iron and steel from rust
2207 J. Ingram—Fire-arms
2208 A. H. Brandon—Balance elevators
2209 J. Taylor—Cutting the pile of piled fabrics
2210 E. Moss—Leather
2211 W. A. Gilbee—Steam generator
2210 J. H. Johnson—Extracting juice from sugar cane
2213 L. J. N. Mourel—Imparting to globes by means of clockwork the various phenomena of the earth
2214 A. M. Clark—Wood pavement
2215 J. Banks—Window fasteners

Dated August 10th, 1870.

2216 T. and C, Stephens—Applying motive power
2217 G. Huntriss, J, Swinburn, and J. Wilson—Supplying mines with lighting gas
2218 J. M. Heppel—Working railway signals
2219 O. Reynolds—Thatch-making machinery
2220 M. Macdermott and A. D. Williams—Drills
2221 C. Gordon—Fire-arms
2222 A. Waddington—Carriages for circular railways.
2223 A. Turner—Carpets
2224 N. D. Spartali—Compressing air
3225 H. and J. Wycherley—Self-acting brake
2226 W. Pilkington—Wheels

Dated August 11th, 1870.

2227 T. S. Prideaux—Regulating the supply of air to furnaces
2228 E. W. P. Taunton—Pumps
2229 T. Penn—Regulating the opening of waterclosets
2230 S. Brooks and J. Standish—Preparing cotton
2231 S. Bennett—Preparation of worts
2232 J. Dudgeon and W. Atkinson—Looms for weaving
2233 W. R. Lake—Button-hole hems
2234 J. S. Davies and W. E. Yates—Looms for weaving
2235 C. D. Abel—Working railway and tramway brakes
2236 J. Starley and W. Hillman—Velocipede wheels
2237 R. E. Barker—Taking bearings

Dated August 19th, 1870.

2238 W. James—Drawing liquids
2239 G. H. Goodman—Crushing ores
2240 T. A. Ellis—Clothes washer
2241 J. Lawton—Mounts for bedsteads
2242—W. O. Johnston—Iron pipes
2243 J. M. Habershon—Treating metal wire
2244 P. Brimelow—Couplings for railway carriages
2245 J. Gale and H. Ormston—Reducing isinglass
2246 I. B. Harris—Elastic tyres for carriage wheels
2247 M. Brown—Carpets
2248 A. Prince—Generating gas
2249 J. M. Hart—Locks
2250 A. M. Clark—Knitting machines
2251 P. Walters—Door fastenings

Dated August 13th, 1870.

2252 C. A. C. Echold—Tobacco pipes
2253 R. Ramsden—Furnaces
2254 T. Unsworth and E. Whalley—Making banding
2255 J. Milroy—Cylindrical piers or foundations
2256 P. Wohack—Bracelet fastenings
2257 J. Robertson—Bending metal
1258 T. Brown—Compressing air
2259 H. C, de Blende—Oil
2260 A. Hayes—Treating grain

Dated August 15th, 1870.

2261 E. C. Williams—Water pressure machinery
2262 D. Ellis—Ginning cotton
2263 R. Charnley—Preventing floats in weaving
2264 W. F. Stanley—True surfaces
2265 J. Hartley—Registering the number of players at various games

Dated August 16th, 1870.

2266 F. R. Window—Obtaining proofs from printing surfaces
2267 E. A. Leigh—Cylinders
2268 G. Speight—Treating glue
2269 H. Bradley—Preparing clay
2270 J. Pain—Velocipedes
2271 W. E. Newton—Detaching boats
2272 A. and L. Turner—Elastic fabrics
2273 E. A. O'Brien—Securing goods

Dated August 17th, 1870.

2274 W. R. Lake—Washers
2275 A. W. Pocock—Measuring water
2976 F. Ziffer—Reeling yarns
2277 C. M. Holland—Rotary engines
2278 W. Harvey—Cocks

Dated August 18th, 1870.

2279 R, Derham—Washing vegetables
2280 R. W. Dee—Drawing liquids
2281 J. J. Shedlock—Purifying oils
2282 W. H. Sim—Rifled small arms
2283 C. Wigg—Sulphuric acid
2284 W. H. Balman—Glass
2285 T. Ivory—Motive power engines
2286 W. R. Lake—Cartridges
2287 E. J. Grabham—Goffering textile fabrics
2288 A. Clegg—Sewing machines

Dated August 19th, 1870.

2289 J. Rawcliffe and W. Bibby—Mules for spinning
2290 A. Cooper—Window blind
2291 W. G. Webb—Printing upon glass
2292 W. Ambler—Spool tubes
2293 D. H. Lowry—Sulphuric acid
2294 W. R. Lake—Exclusion of dust from axle journals
2295 J. Howard and E. T. Bousfield—Cutting grass

Dated August 20th, 1870.

2296 W. Firth—Wheels
2297 J. J. Hays—Utilising sewage
2298 G. Duncan, G, Hutchin, and S. M. Harrison—Discharging caustic soda
2299 J. W. Broadbent—Cleaning boilers
2300 H. Hughes—Trimmings, &c.
2301 A. I. Maxfield—Sewing machines
2302 F. S. Clarke...Preservation of gloves
2303 C. Morfit—Superphosphate of lime
2304 J. H. Banks—Raised pattern blocks
2305 R. C. Rapier—Locking apparatus for railway switches
2306 J. Lewis—Lithographic printing
2307 C. F. Collom—Cleaning ores
2308 C. Pennington—Pavement

Dated August 22nd, 1870.

2309 W. Thomson—Window blinds
2310 F. A. Paget—Pulp for paper
2311 W., J., and W. M. Richard—Printing machines
2312 S. Darby—Fluid meat
2313 P. Motiron, P. Huchard, and A. Drouot—Cord

Dated August 23rd, 1870.

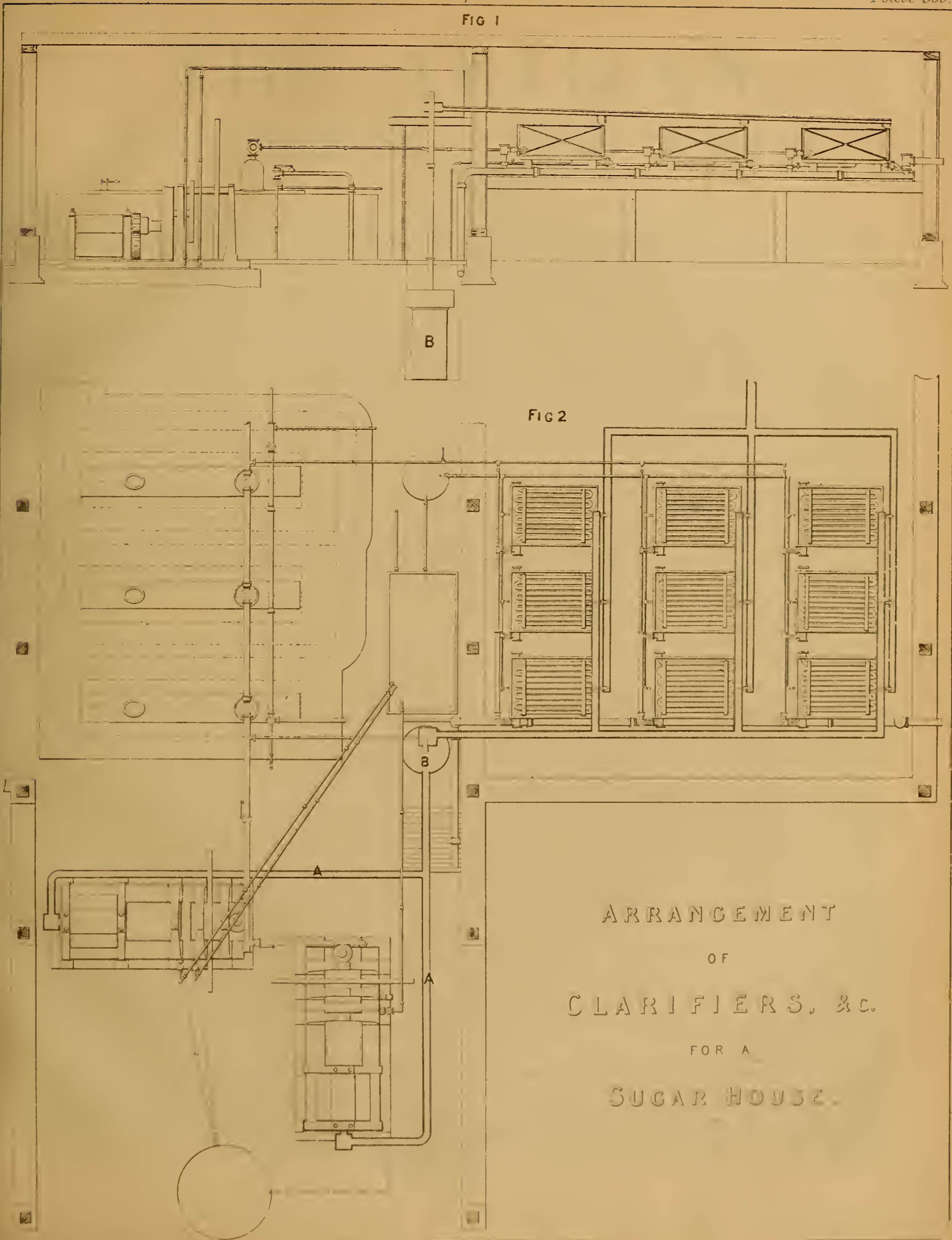
2314 I. N. Jakins—Raising bedridden or invalid persons
2315 S. Farron—Diminishing valves
2316 M. Macdermott and A. D. Williams—Boring rock
2317 C. W. Harrison—Fire-arms
2318 W. J. Hay—Coating metal sheathing
2319 F. Holmes—Pumps
2320 J. Lloyd—Oil
2321 J. Robinson and J. Smith—Cutting wood into shavings
2322 J. A. Hogg—Miner's lamps
2323 W. R. Lake—Knitting machines

Dated August 24th, 1870.

2324 W. Braidwood—Printing presses
2325 F. J. R. Carulla—Purifying iron
2326 T. and J. Bibby and J. and W. Baron—Paper bags
2327 A. G. Day—Pavement
2328 W. Berry—Mud and water cart
2329 W. Goulding and A. Hill—Mowing machines
2330 W. E. Newton—Printing machinery
2331 A. M. Silber—Lighting

Dated August 25th, 1870.

2332 I. Brown—Lead pipes
2333 T. A. Letts—Railway tickets
2334 A. Alexander and D. Lansley—Water feeders
2335 H. J. H. King—Feeding wool, &c.
2336 W. Bullock—Waterproof garments
2337 P. M. Parsons—Artificial fuel
3338 A. V. Newton—Liquid meters
2339 W. E. Newton—Electric clockwork
2340 S. D. Tillman—Tramways
2341 C. Robson—Scutching flax



ARRANGEMENT

OF

CLARIFIERS, &c.

FOR A

SUGAR HOUSE.

THE ARTIZAN:

No. 10.—Vol. IV.—Fourth Series.—Vol. XXVIII. From the Commencement.

1st OCTOBER, 1870.

ARRANGEMENT OF CLARIFIERS &c., FOR A SUGAR HOUSE.

(Illustrated by Plate 365.)

Continued from Page 122.

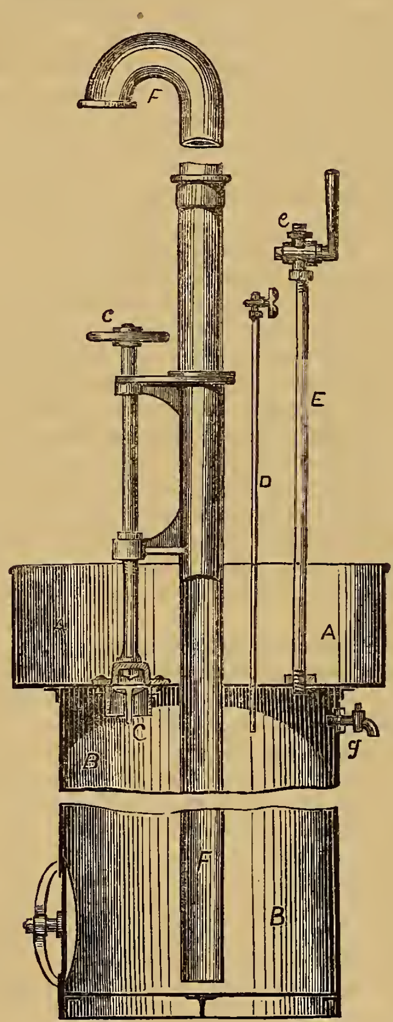
In giving a description of a Sugar Mill in The Artizan (see p. 122) we pointed out that, although many other processes had been invented for the purpose of expressing the juice from sugar canes, they were all practically useless from their inability to devour, in anything approaching to a reasonable time, the enormous quantity of canes that are required for supplying sufficient juice to the boiling house. The process of forcibly expressing the juice from the canes, by the aid of roller mills has, however, one serious drawback, viz.: that besides obtaining what is wanted, a considerable quantity of what is not wanted comes with it.

The canes, as they issue from a good mill, have somewhat the appearance of a sheet of pasteboard, the quantity of which amounts to about 20 per cent. of the quantity that entered the mill. It is comparatively dry to the touch, but is found to consist of about one half juice, the remainder being weedy fibre, and a small proportion of silica. This cane trash, or megass ought, we consider, to supply sufficient fuel for working the whole plant for the manufacture of sugar, and thus entirely supersede the employment of coal or weed, but we must leave this subject for future consideration.

The remaining 80 per cent. consists of what is commonly called cane juice, with a small amount of weedy fibre held in suspension. The term cane juice can, however, scarcely be applied correctly to the liquid under consideration, as it contains, in addition to sugar and water, small quantities of various deleterious substances, forced out of the canes by the intense pressure to which they have been subjected. These impurities consist of green feculae, green wax, gum, gluten, and various salts of lime, potash, soda, &c., and a peculiar substance, the composition of which is unknown. The respective amount of their impurities varies considerably in different species of canes, and also from various other causes, but they appear to exist in greater or less proportion in all cane juice, besides this, there is usually a certain amount of acid, caused by the exposure of the ends of the canes since the time they were cut in the field. It will be readily perceived that a mixture of this description in a climate where the normal temperature may always be taken at somewhat above 80° is excessively liable to ferment, and it is, therefore, very important that it should be left in that state as short a time as possible. For this purpose it is advantageous to have the mill as near to the clarifiers as possible, so that time may not be lost, the juice having to travel long distances through gutters. It was the practice in the West Indies, when steam mills were first adopted, to erect them at a considerable distance from the boiling houses, the planters being under the impression that such a precaution was necessary to save the shingles of which the roofs are composed from being ignited by the sparks from the chimneys. It is, consequently, not at all unusual to find that there is a distance of 150 to 200ft. between the mill and the clarifiers, the communication between them being effected by means of an open gutter along which the cane juice leisurely travels. This system is much to be deprecated, as the juice must be treated with an extra quantity of lime to neutralize the acidity thus acquired, which is well known to darken the colour of the sugar. The danger of fire from the boiler chimney appears to be very small; at all events, a galvanised iron roof would insure the buildings much more efficiently.

In Plate 365 the arrangement of a portion of a sugar house is shown including the steam boilers, mills, monte jus and clarifiers, where it will be observed, the distance between the mills and clarifiers is as much shortened as possible. In this case the juice first passes from the mill through a set of graduated copper strainers, which are simply trays with perforated bottoms, and usually consisting of a set of three placed one above the other, the holes in the top tray being larger than those in the middle one, while those in the lowest tray are still smaller. These trays arrest nearly all the weedy particles of the cane on their course to the monte jus, the large pieces being collected in the top tray, the two others performing the duty towards the various other sized particles. The juice thus freed from mechanical impurities flows into the monte jus shown at A plate 365, and upon a larger scale in the accompanying engraving. In the older mills, and in fact, in most mills existing at the present time, pumps are used for the purpose of elevating the cane juice, these pumps being usually worked by an excentric fitted to an extension of the spindle of the top roller. This plan, however, we consider is objectionable inasmuch that the juice is kept too long before being heated, and, therefore, as has been already observed, at the precise temperature at which fermentation is most active, and also that the mixture of grease and metal from the working parts of the machinery is liable to be pumped up with the juice. With the monte jus these objections disappear as the heat of the steam used in forcing up a "charge" of juice into the clarifiers leaves it sufficiently warm to impart a considerable amount of heat to the next charge, thereby at once retarding, if not arresting, fermentation; also, as there are no working parts in its construction, no grease is required for its proper action.

The construction and method of working a monte jus is very simple as will be seen from the following description of the accompanying engraving. The body of the monte jus consists of two parts A and B, separated by a steam-tight diaphragm; the upper part A is for the reception of the juice from the mill, while the charge in the lower portion is being elevated, and is made of sufficient capacity for that purpose. When the lower portion B of the monte jus is empty, the valve C is raised by turning the handle c, while at the same time the cock of the air pipe D is opened. The juice contained in the upper portion or receiver A, immediately descends through the valve C, any air that may be contained in the chamber B, escaping through the air pipe D. It will be noticed that this air pipe extends about 6in. into the lower chamber B. This is for the purpose of ascertaining when the chamber is sufficiently full; the escape of air through the pipe D being of course stopped immediately the juice reaches its lower end. The cessation of the whistling noise made by the air rushing through the end of this air pipe, constitutes the signal for screwing down the valve C, to prevent any further flow of juice into the lower part of the monte jus. The air cock is then closed, and the steam cock e of the steam pipe E communicating with the boilers, is opened, when the empty space between the surface of the juice, and the top of the lower chamber B is immediately filled with steam, which at once commences to drive the juice out through the discharge pipe F. This pipe being carried down to within a short distance of the bottom of the monte jus, nearly the whole of the contained liquid is forced out of the lower chamber. As soon as any indications of steam appear at the mouth of the discharge pipe, the steam cock e is shut, and the valve C and air cock D is opened to let in a fresh charge. It will thus be seen that the action of the monte jus is exceedingly simple, only one precaution being necessary, viz., to shut the valve C through which the juice is running, in time. If the juice be allowed to reach the top plate of the chamber B, the steam when let on through the pipe E will mix with, and boil the juice, but will not elevate it, and we have known considerable difficulty and delay arising from this circumstance. As a precaution against carelessness, we should recommend an overflow cock g to be fitted to the shell B a few inches below the top, so that the superabundant juice might be drawn off. The cane-juice as it comes from the monte jus, is, as was before remarked, sufficiently warm to retard fermentation on its way to the clarifiers, and also, while waiting in the clarifiers, until a sufficient depth has accumulated to admit of their being heated.



Although clarifiers of various descriptions have been adopted and recommended, they may be simply divided into two classes, viz., those worked by heat from the evaporating pans (or in some cases by a separate fire), which is regulated by a damper, and those worked by steam either from the boiler or the exhaust steam from the engine. The arrangement shewn in plate 365 consists of a set of nine steam clarifiers, as we consider that where fuel is expensive—as is the case in nearly all sugar growing countries—the economy of heating by steam more than compensates for the considerable excess of first cost. This method also possesses the advantage of enabling the heat being regulated with greater nicety, and of being shut off or let on more speedily than is possible with an open fire.

(*To be continued*).

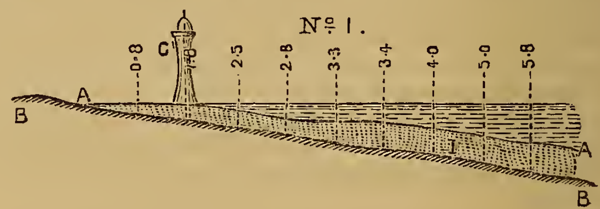
REPORT ON THE SUEZ CANAL.

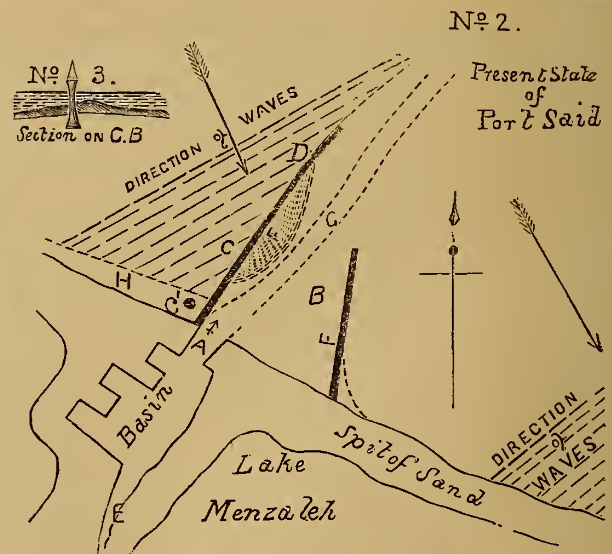
By T. Login, C.E., Executive Engineer.

[We have received from Mr. Login a very able report, embodying his opinions respecting the Suez Canal. It is too lengthy to be printed *in extenso*; the observations, however, of such an eminent authority upon the subject, together with his anticipations of the future, are very in-interesting.]

In continuation of my report on Irrigation in Egypt, now submitted, and in accordance with a letter dated 4th November, 1869, from the Home Government, I have the honour to forward a report on my late inspection of the Suez Canal, which, through the kindness of the Canal authorities, I was enabled to do in a satisfactory manner.

On my first visit to Egypt in 1856, I could not help observing that, though the harbour of Alexandria is close to the most western mouth of the Nile, yet during these last 3,000 years or so, no perceptible change in the depth of the harbour has been observed, so far as I could learn, and on my return voyage I made particular inquiries on the subject, which led me to the conclusion that the current which enters the Mediterranean at Gibraltar, passing along the north coast of Africa in an easterly direction, which ultimately passes along the south coast of Europe, causing a considerable current through the straits of Messina, and ultimately returning to the Atlantic by an under current through the straits of Gibraltar, must be one of the chief causes why there





NOTE.—At the depth of 10 metres the deposits have been still greater, for this depth to 10 metres is now 500 metres further out than it was seven years before.
No. 1.—A A, present bed; B B, former bed; C/, Light-house; I, silted up since 1861.
No. 2.—C/, Lighthouse; E, Canal; F, sand and mud deposit; G, deepwater channel; H, land reclaimed. The arrows point to prevailing winds.

should be no deposit in the harbour of Alexandria, and that we should look for it along the coast east of the mouths of the Nile. So satisfied was I on this point that I made arrangements to remain in Egypt for a short time on my return home in 1867, so that I might visit Port Said, and see if there were not deposits taking place at that spot, for I considered the breakwater there must act in the same manner as spurs on our rivers in Upper India, and cause a deposit east and west of them. Sickness, however, prevented my being able to remain in Egypt, so I had to defer my visit till this present occasion on my return to India.

While in England, however, I had on two or three occasions read papers in connection with this question, the "abrading and transporting powers of water,"* which, I believe, increases in some ratio as the velocity increases, and decreases as the depth increases; so I may now simply state that my late inspection confirms these views, and that I found that a considerable deposit has taken place and is still going on.

I was informed by the engineer at Port Said, that it was during the fall of the year that deposits chiefly took place, that is, while the Nile is in flood, that the prevailing wind was north-westerly, but towards the afternoon it usually veered round to a north-easterly direction; but any one who has sailed in the Mediterranean knows that the winds are not constant like the "trade winds" or the monsoons, so, though the prevailing winds may be north-western, it is by no means intended to affirm that there are never easterly gales along the coast. Now, if the wind is the sole cause of the transport of the Nile silt it can only be by the waves breaking on the beach, and if so, surely in these last 3,000 years some of this silt would find its way westward to Alexandria, and also the deposits at Port Said would vary more according to the winds rather than to the floods down the Nile; consequently, as these floods bring to the sea this earthy matter, and fresh water being lighter than that of the sea, the fresh water holding this in suspension floats on the salt water, and by this current in the Mediterranean is transported eastward, ultimately uniting with it, and depositing its load along the coast.

By the accompanying sketch (No. 2) of Port Said it will be observed that the site of this port is on a narrow spit of sand which runs along the coast, commencing near the most eastern mouth of the Nile, and extending eastward for many miles further. Behind this spit there is the shallow lake Menzaleh, while on the northern face of it is the Mediterranean Sea.

The slope that the sea beach here takes is as near as possible 1 in 300;† the depths along the site of the present breakwater previous to commencing work were as per sketch No. 1.

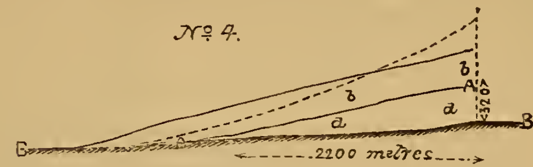
The advance along the sea coast on the western side of the breakwater is considerable, as it extended along the beach westward 540 metres in November, 1861, when it had only advanced 70 metres seaward.

The advance in—

June,	1864,	westward, was about	1000	metres and	140	seawards.
March,	1865,	" "	1500	"	160	"
November,	"	" "	1800	"	225	"
January,	1867,	" "	2000	"	265	"
June,	1868,	" "	2200	"	320	"

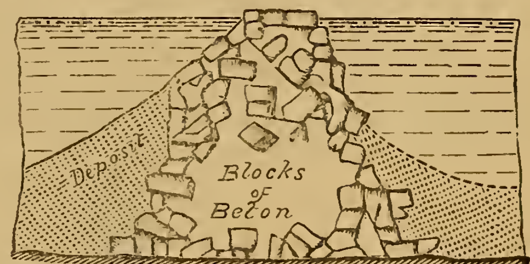
From this it appears the land which may be reclaimed already covers an area of little short of 100 acres, and as it protrudes out into the sea, before long this reclaimed land will become the favourite site for private residences owing to the sea breeze, and the value of this property will no doubt hereafter go a considerable way to repay for any future extension there may be necessary for the breakwater.

The present advance seems to be at the 10 metre or 5½ fathom depth some 75yds. yearly, while in the same period the sea has receded some 50yds. a year; but I do not anticipate that the advance will be so rapid in future years as it has been up to the present time; for, as the deposit extends seaward, so will it extend westward six or seven times as far: thus the area will increase over which there will be deposit in the same ratio as a triangle having its side in the proportion of one side perpendicular to six or seven horizontal; thus—

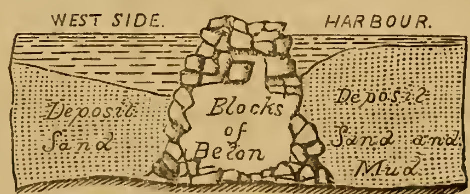


That is, though the space *a* may be filled up in half a dozen years, it does not follow that the space *b* will also get filled up in six years more, but that probably it will take some twenty years to make an equal advance at the back of the breakwater. Probably hereafter the coast line will follow more the direction of the dotted line, but, judging from what I have seen, I do not anticipate that this will prove a *very* expensive item, concerning which I shall say a few more words further on.

On the west side of the breakwater, that is, the exposed side, I observed a very remarkable fact when examining the sections, namely, where the depth of water exceeded three metres it was always deeper away from the breakwater than just at the side of it, but where the depth was less at the side than three metres it was shallower; thus—



SECTION NEAR . D . No. 5.



SECTION NEAR . B . C . No. 6

There was a similar effect on the east or harbour side, and this probably arises from the beat of the sea on the breakwater agitating the water between the blocks and thereby preventing deposit in their vicinity.

Regarding the deposit on the east or harbour side it is not such a serious matter as I feared, for so long as the silt only comes through between the blocks, and not round the outer end of the breakwater, I do not anticipate much trouble, for in the former case the best plan is to leave it alone and keep the deep channel for ships well away from it.

At first this deep channel was 150 metres from the breakwater, but now it is 200 metres; I think myself it would be still better to have it removed 250 metres, or nearly 300 yards, away from the breakwater up to the point where the sea reaches, but beyond this and all the way inland there can be no objection to dredging close up to the breakwater; for, where the deposits on the west side of it are level with high water it is evident there can be no longer a passage of silt through the breakwater; and as the blocks of Beton were in the first instance deposited in comparatively deep water, there can be no danger of disturbing them; consequently a wharf along this portion could be constructed at little expense for ships to lie along-side of it.

The deposit along the east side of the breakwater where it had silted up to high water mark appeared to be of much lighter consistency than on the other side; for while on the west or Nile side the deposit was sand, on the east side there appeared to be a large admixture of mud, and the more inland the more did mud predominate.

The ship I passed through the canal in was anchored about opposite the Light-house at the point A of sketch No. 2, and on heaving up the anchor a quantity of Nile mud was attached to the chain, a sample of which is forwarded with the report.* Now as this was in the line of the spit of sand

* See THE ARTIZAN for 1869, pp. 30, 99, 128, 151, and 174.

† The slope of a sea beach appears chiefly to depend on the nature of the materials it is composed of. Thus, at Madras, where the sand is very coarse, the slope seaward is comparatively steep, though exposed to a heavy surf; while at Weston-super-Mer, on the Bristol Channel, where there is clay, the slope is barely 1 in 500, while where there is sand it is about 1 in 100. The Nile sand is not coarse, being much the same as the sand in Upper India. Where there are pebbles and boulders the slopes increase accordingly varying according to the size and beat of the sea.

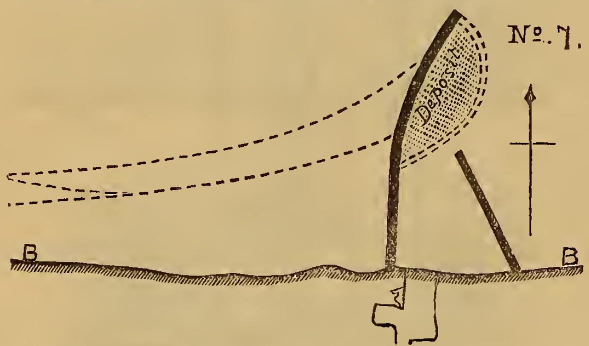
* This mud, if it was spread over the reclaimed land, would most certainly be a great improvement to the sand people have now to walk over, and also if irrigated would prove in time a rich soil for gardens.

before referred to, it appears that only fine mud is deposited at this spot, and as sand is the chief substance held in suspension by the waves beating on the shore, this I think convincingly proves that the water in the harbour opposite the Light-house cannot be much agitated. And as I could not observe any current in the canal, and the water was comparatively clear at the upper end of the Grand Basin, we may rest satisfied that there is no great danger of large deposits either in the canal itself or the basin, so what deposits take place will for the future be chiefly beyond the Light-house.*

The important question now to consider is—Will this deposit be to such an extent as to endanger the navigation, and will the dredging here be so expensive as to make the canal an unprofitable undertaking in a financial point of view? To this would I beg to draw particular attention, for in my opinion the chief difficulty in working the canal and keeping an open channel lies between the Light-house and the open sea, all other difficulties from Port Said to the Red Sea being of secondary importance.

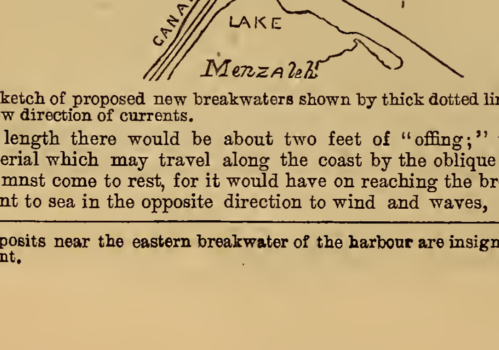
I have before said that the advance of the land seaward is about 75yds. a year at the bottom, and 50yds. at the surface, and the slope of the shore seaward is about 1 in 300. That is, to have six fathoms of water at the end of the breakwater, it must extend beyond the dry land portion about two miles; and, allowing these two miles a deep channel, at least 100yds. wide will have to be kept open. The question is—Will not dredging out this channel to a depth of five fathoms (30ft.) be a very expensive operation, and is there no way by which this may be avoided?

It has been proposed, I believe, to slightly change the direction of the breakwater hereafter, bending the outer portion in a more easterly direction, when it is supposed it will give a set to the current seaward, and deposit the silt in deep water. My experience of spurs on our river leads me to doubt this, and though there may be deep water along the outer end of the breakwater on the western side for a short distance, and even a deep hole scooped out at the extreme end, yet the current will sweep round the point, and deposit the mud and sand along the east side; thus:—



And it will be no easy matter to keep a deep channel through this deposit, where the depth is 30ft., and the Mediterranean is not always a tranquil sea to work in.

What I therefore venture to suggest for consideration, is to extend the present breakwater, not in a north-easterly direction, but in a north-westerly one, running it out, as a sailor would say, in the teeth of the prevalent wind, or at angle of 45 degrees with the coast, and for every three feet of



No. 8.—Sketch of proposed new breakwaters shown by thick dotted lines. The arrows show direction of currents.

additional length there would be about two feet of "offing;" thus any heavy material which may travel along the coast by the oblique action of the waves mnst come to rest, for it would have on reaching the breakwater to travel ont to sea in the opposite direction to wind and waves, which is not likely to occur. By this modification it appears to me that there would be a great deposit all along the sea face of the Delta of the Nile, which in the course of centuries may affect the present geography of Egypt along the sea coast, but is a matter which may safely be left to the Duke of Suez's great-grand-children to consider. Our present question is—Would this arrangement more perfectly stop the mud and sand brought down by the Nile turning the end of the breakwater, and thus closing up the entrance to Port Said; and this I believe it would, though some silt would still find its way between the blocks of Beton, and even round the end of the breakwater. But as this silt, as has been already said, is much finer or lighter than the land on the western side, it would be all the more easily affected by scour; so that the question is—How is this scouring power to be obtained? By another breakwater placed in a slanting direction, say at an angle of 60 degrees with the coast, a funnel shaped channel would be obtained, as shown in No. 8.

By such an arrangement I believe a sufficient scour may be obtained so as to keep a deep channel along the inner surface of the outer breakwater and that it would only deposit a comparatively small quantity within the present harbour, carrying most of it away eastward to be deposited either out at sea in deep water, or behind the eastern harbour breakwater, where it can do no harm; another advantage is that this plan admits of two ways for a ship to enter and leave the harbour; a very important point for ships with the wind blowing on to the coast.

Having, I hope, with sufficient clearness explained my views with respect to Port Said, before speaking of the canal itself I may make a few remarks about the Suez end of the canal. Here at spring tides there is a rise and fall of 5ft., and 3ft. at neap tides, while at Port Said the rise and fall is only 9in., though during strong gales the Mediterranean rises 18in. The level of the two seas may be taken as idontical, for by the last series of levels the differences was found to be only 3in., the Mediterranean sea being the higher of the two.

(To be continued.)

* The deposits near the eastern breakwater of the harbour are insignificant up to the present.

BRITISH ASSOCIATION.

PRESIDENT'S ADDRESS IN SECTION B—(CHEMICAL SECTION.)

By Professor H. E. Roscoe, Ph.D., F.R.S., President.

Gentlemen.—In the midst of the excitement of the horrible war in which the two most scientific nations of the Continent are now plunged, let us endeavour to turn our thoughts into channels more congenial to the scientific inquirer; and allow me to recount to you, as far as I am able, the peaceful victories which, since our meeting in Exeter, have been achieved in our special department of chemistry. But first may I be permitted to draw your attention to the fact that whilst, on the one hand, we hear of professors of chemistry and their students volunteering in the humane offices of field apothecaries or hospital attendants, we learn, on the other hand, that a distinguished chemist has accepted the chairmanship of a scientific committee called together for the express purpose of employing all the resources of modern chemistry in the horrible destruction of their fellow creatures; for to what do such resources in the last instance amount, but to sudden explosion, fire, or poison? The application of such means in such an age as this cannot surely be justified in any sense either by patriotism or public duty. And yet, in spite of all this, it is, in my mind, mainly to the brotherly intercourse of those interested in science and in its applications to the arts and manufactures in different countries that we must look as the small but living fire, which, in the end, will surely serve to melt down national animosities, and to render impossible the breaking out of disasters so fatal to the progress of science and to the welfare of humanity as that of which we are now, unfortunately, the spectators.

With regard to the position of chemical science at the present moment, it will not take a careful observer long to see that, in spite of the numerous important and brilliant discoveries of which every year has to boast, we are really but very imperfectly acqnainted with the fundamental laws which regulate chemical actions, and that our knowledge of the ultimate constitution of matter upon which those laws are based is but of the most elementary nature. In proof of this I need only refer to the different opinions expressed by our leading chemists, in a discussion which lately took place at the Chemical Society on the subject of the atomic theory. The president (Dr. Williamson) delivered a very interesting lecture, in which the existence of atoms was treated as "the very life of chemistry." Dr. Frankland, on the other hand, states that he cannot understand action at a distance between matter separated by a vacuous space; and, although generally granting that the atomic theory explains chemical facts, yet he is not to be considered as a blind believer in the theory, or as unwilling to renounce it if anything better presented itself. Sir B. C. Brodie and Dr. Odling both agree that the science of chemistry neither requires nor proves the atomic theory; whilst the former points out that the true basis of this science is to be sought in the investigation of the laws of gaseous combination or the study of the capacity of bodies for heat, rather than in committing ourselves to assertions incapable of proof by chemical means. Agreeing in the main myself with the opinions of the last chemists, and believing that we must well distinguish between fact and theory, I would remind you that Dalton's discovery of the laws of multiple and reciprocal proportions—I use Dr. Odling's word—as well as the differences in the power of hydrogen replacement in hydrochloric acid, water, ammonia, and marsh gas, are facts, whilst the explanation upon the assumption of atoms is, as far as chemistry is as yet advanced, a theory. If, however, the existence of atoms cannot be proved by chemical phenomena we must remember that the assumption of the atomic theory explains chemical facts as the undulatory theory gives a clear view of the phenomena of light. Thus, for instance, one of the most important facts and relations of modern chemistry which it appears difficult, if not impossible, to explain without the assumption of atoms, is that of isomerism. How, otherwise than by a different arrangement of the single constituent particles, are we to account for several distinct substances in which the proportions of carbon, hydrogen, and oxygen are the same? Why, for instance, should forty-eight parts by weight of carbon, ten of hydrogen, and sixteen of oxygen united together be capable of existing as three different chemical substances unless we presuppose a different statical arrangement of the parts by which these differences in the deportment of the whole are rendered possible? If, then, it be true that chemistry cannot give us positive information as to whether matter is infinitely devisible, and therefore continuous, or consists of atoms and is discontinuous, we are in some degree assisted in this inquiry by deductions from physical phenomena which have been recently pointed out by the genius of Sir William Thomson. He argues from four different classes of physical phenomena, and comes to the conclusion, not only that matter is discontinuous, and, therefore, that atoms and molecules do exist, but he even attempts to form an idea of the size of these molecules, and he states that in any ordinary liquid, transparent or seeming opaque solid, the mean distance between the centres of contiguous molecules is less than the hundred millionth, and greater than the two-thousand millionth of a centimetre. Or, to form a conception of this coarse-grainedness, imagine a rain-drop or globe of glass as large as a pea, to be magnified up to the size of the earth, each constituent molecule being magnified in the same proportion; the magnified structure would be coarser-grained than a heap of small shot, but probably less coarse-grained than a heap of cricket balls.

There is, however, another class of physical considerations which render the existence of indivisible particles more than likely. I refer to the mechanical theory of gases, by means of which, thanks to labours of eminent English and German philosophers, all the physical properties of gases, their equal expansion by heat, the laws of diffusion, the laws of alteration of volume under pressure, can be shown to follow from the simple laws of mechanical motion. This theory, however, presupposes the existence of molecules, and in this direction again we find confirmation of the real existence of Dalton's atoms. Indeed, it has been proved that the average velocity with which the particles of oxygen, nitrogen, or common air are continually projected forward, amounts, at the ordinary atmospheric pressure, to 50,000 centimetres per second, whilst the average number of impacts of each of these molecules is 5,000 millions per second. The mention of the molecular motions of gases will recall to the minds of all present the great loss which English science has this year sustained in the death of the discoverer of the laws of gaseous diffusion. Throughout his life Graham's aim was the advancement of our knowledge in the special subject of the molecular properties of gases. With this intent he unceasingly laboured up to the moment of his death, in spite of failing health and pressure of official business, unfolding for posterity some of the most difficult as well as the most interesting secrets of nature in this branch of our science. "What do you think," he writes to Hofmann, "of metallic hydrogen, a white magnetic metal?" And yet now, through his labours, the fact of the condensation of hydrogen in the solid state by metallic palladium, and to a less extent by other metals, has become familiar to all of us. Then, again, I would remind you of Graham's recent discovery of the occlusion of hydrogen gas in certain specimens of meteoric iron, whilst earth-manufactured iron contains not hydrogen but absorbed carbonic oxide gas, proving that the meteorite had probably been thrown out from an atmosphere of incandescent hydrogen existing under very considerable pressure, and therefore confirming in a remarkable degree the conclusions to which spectrum analysis had previously led us. The position in the ranks of British science left by Graham's death will not be easily filled up; he accomplished to a certain extent for dynamical chemistry what Dalton did for statical chemistry, and it is upon his experimental researches in molecular chemistry that Graham's permanent fame as one of England's greatest chemists will rest.

As closely connected with the above subjects, I have next to mention a most important research by Dr. Andrews, of Belfast, which, marking an era in the history of gases, shows us how our oldest and most cherished notions must give way before the touchstone of experiment. No opinion would appear to have been more firmly established than that of the existence of three separate states or conditions of matter, viz., the solid, the liquid, and the gaseous. A body capable of existing in two or more of these states was thought to pass suddenly from one to the other by absorption or emission of heat, or by alterations of the superincumbent pressure. Dr. Andrews has shown us how false are our views on this fundamental property of matter, for he has proved that a large number of, and probably all, easily condensable gases or vapours possess a critical point of temperature at and above which no increase of pressure can be made to effect a change into what we call a liquid state, the body remaining as a homogeneous fluid; whilst below this critical temperature certain increase of pressure always effects a separation into two layers of liquid and gaseous matter. Thus, with carbonic acid, the point of critical temperature is 30·92° C., and with each given substance this point is a specific one, each vapour exhibiting rapid changes of volume and flickering movements when the temperature or pressure was changed, but showing no separation into two layers. Under these circumstances, it is impossible to say that the body exists either in the state of a gas or of a liquid; it appears to be in a condition intermediate between the two. Thus, carbonic acid, under the pressure of 108 atmospheres, and at 35·5° C., is reduced to the 1-430th of the volume which it occupies at one atmosphere, it has undergone a regular and unbroken contraction, and it is a uniform fluid: if we now reduce the temperature below 31° C. the liquid condition is assumed without any sudden change of volume or any abrupt evolution of heat. We can scarcely too highly estimate the value of the researches of Andrews.

As examples of the power which modern methods of research give of grappling with questions which only a few years ago were thought to be insoluble, I may quote the beautiful observations, now well known, by which Lockyer determined the rate of motion on the sun's surface, together with those of Frankland and Lockyer respecting the probable pressure acting in the different layers of the solar atmosphere; and, lastly, the results obtained by Zöllner, respecting solar physics, and especially the probable absolute temperature of the sun's atmosphere, as well as that of the internal molten mass. These last results are so interesting and remarkable as being arrived at by the combination of recent spectroscopic observation with high mathematical analysis, that I may perhaps be permitted shortly to state them. Starting from the fact of the eruptive nature of a certain class of solar protuberences, Zöllner thinks that the extraordinary rapidity with which these red flames shoot forth proves that the hydrogen of which they are mainly composed must have burst out from under great pressure; and if so, the hydrogen must have been confined by a zone or layer of liquid from which it breaks loose. Assuming the existence of such a layer of incandescent liquid, then applying to the problem the principles and methods of the mechanical theory of gases, and placing in his formulæ the data of pressure and rate of motion as observed by Lockyer on the sun's surface, Zöllner arrives at the conclusion that the difference of pressure needed to produce an explosion capable of projecting a prominence to the height of 3·0 minutes above the sun's surface, a height not unfrequently noticed, is 4,070,000 atmospheres. This enormous pressure is attained at a depth of 139 geographical miles under the sun's surface, or at that of 1-658th part of the sun's semi-diameter. In order to produce this gigantic pressure the difference in temperature between the enclosed hydrogen and that existing in the solar atmosphere amounts to 74,910° C. In a similar way Zöllner calculates the approximate absolute temperature of the sun's atmosphere, which he finds to be 27,700° C.—a temperature about eight times as high as that given by Bunsen for the oxyhydrogen flame, and one at which iron must exist in a permanently gaseous form.

Passing on to more purely chemical subjects, we find this year signalised by the re-determination of a most important series of chemical constants, viz., that of the heat of chemical combination, by Julius Thomsen, of Copenhagen. This conscientious experimentalist asserts that the measurements of the heat evolved by neutralising acids and bases hitherto considered most correct, viz., those made with a mercury calorimeter by Favre and Silbermann, differ from the truth by 12 per cent., whilst the determination by these experimenters of the heat of solution of salts is frequently 50 per cent. wrong. As the result of his numerous experiments, Thomsen concludes that when a molecule of acid is neutralised by caustic alkali the heat evolved increases nearly proportionally to the quantity of alkali added until this reaches 1, ½, ⅓, or ¼ of a molecule of alkali, according as the acid is mono-, di-, tri-, or tetra- basic. Exceptions to the law are exhibited by silicic, and also partly by boracic, orthophosphoric, and arsenic acids. In the two latter the heat of combination is proportional for the two first atoms of replaceable hydrogen, but much less for the third atom. A second unexpected conclusion which Thomsen draws from his calorific determinations is that sulphuretted hydrogen is a mono-basic acid, and that its rational formula is therefore HSH.

Another important addition made to chemistry since our last meeting is a new, very powerful, and very simple form of galvanic battery, discovered, though not yet described, by Bunsen. In this second Bunsen's battery only one liquid, a mixture of sulphuric and chromic acids, and, therefore, no porous cells, are employed. The plates of zinc and carbon can all be lowered at once into the liquid and raised again at will. The electromotive force of this battery is to that of Grove—the most powerful of known forms—as 25 to 18; it evolves no fumes in working, and can be used for a very considerable length of time without serious diminution of the strength of the current, so that Bunsen writes me that no one who has once used the new battery will ever think of again employing the old forms. I had hoped to be able to exhibit to the section this important improvement in our means of producing a strong current, but war has demanded the use of other batteries, and Bunsen has been unable to send me a set of his new cells.

Amongst the marked points of interest and progress in inorganic chemistry during the past year, we have to notice the preparation of a missing link amongst the oxysulphur acids by Schützenberger. It is the lowest known, and may be called hydrosulphurous acid, H_2SO_2. The sodium salt, $NaHSO_2$, is obtained by the action of zinc on the bisulphite; as might be expected, it possesses very powerful reducing properties, and bleaches indigo rapidly. The metallic vanadates have also been carefully examined, and the existence of three distinct series of salts proved corresponding to the phosphates, viz., the ortho or tribasic vanadates, the pyro or tetrabasic vanadates, and the meta or monobasic vanadates. Of these the ortho salts are most stable at a high temperature, whilst, at the ordinary atmospheric temperature, the meta salts are most stable. In the phosphorus series, as is well known, the order of stability is the reverse; and thus the points of analogy and of difference between phosphorus and vanadium become gradually apparent.

As an illustration of the results of modern organic research—for in viewing the year's progress in this ever widening branch of chemistry it is impossible to do more than give a few illustrations—I may quote Baeyer's remarkable investigations on mellitic acid. Originally discovered by Klaproth in honeystone or mellite (a substance which yet remains the only source of the acid), mellitic was supposed to be a four-carbon acid. Baeyer has quite recently shown that the acid contains twelve atoms of carbon, or has a molecular weight three times as great as was originally supposed. He has shown that mellitic acid is benzolhexacarbonic acid, $C_{12}H_6O_{12}$, or benzol in which the six atoms of hydrogen are replaced by the monad radical, carboxyl (COOH); as benzoic is benzol-mono-carbonic acid, or benzol in which one of hydrogen is replaced by carboxyl. The most interesting portion of Baeyer's research, however, lies in the intermediate acids, partly new and partly acids already prepared, which he has shown lie between mellitic and benzoic acid, and in which from one to six atoms of hydrogen in benzol are respectively replaced by carboxyl. Nor is this all, for he has proved that, with two exceptions, each of these six acids is capable of existing in three isomeric modifications, thus giving us an insight into the arrangement of the molecule of these aromatic compounds. For the simplest mode of explaining these numerous isomers is that given by Baeyer in the different order in which the several atoms of hydrogen in the benzol molecule are replaced. Thus, in the first, or ortho, series, the hydrogen atoms in benzol, being numbered in regular succession, are replaced in the same regular succession; in the second, or meta, series, the order is 1, 2, 3, 5, &c.; whilst the third, or para, series, takes open order, as 1, 2, 4, 5, &c. Thus we have—

	Ortho series.	Para series.	Meta series.
$C_{12}H_6O_{12}$ Hexabasic	Mellitic or Benzolhexacarbonic.		
$C_{11}H_6O_{10}$ Penta ...	Unknown.		
$C_{10}H_6O_8$ Tetra ...	Pyromellitic or Benzoltetracarbonic.	Isopyromellitic.	Unknown.
$C_9H_6O_6$ Tri	Trimesinic or Benzoltricarbonic.	Hemimellitic.	Trimellitic.
$C_8H_6O_4$ Di	Phthalic or Benzoldicarbonic.	Isophthalic.	Tetrephthalic.
$C_7H_6O_2$ Mono... ...	Benzoic or Benzolmonocarbonic.		

Amongst the most interesting series of new organic bodies are those in which tetrad silicon partly replaces carbon. Our knowledge of these substances is gradually becoming more complete; the last new member prepared by Friedel and Ladenburg is silico-propionic acid—

$$\begin{matrix} C_2H_5 \\ SiO_2H \end{matrix}$$

the first of a series of carbo-silicic acids containing the radical SiO_2H. The interesting researches of Matthiessen and Wright on morphine and codeine have thrown a new light on the constitution of these opium alkaloids. Treated with hydrochloric acid morphine loses one molecule of water, and gives rise to a new base called apomorphine, thus:—

$$\underbrace{C_{17}H_{19}NO_3}_{\text{Morphine.}} = H_2O + \underbrace{C_{17}H_{17}NO_2}_{\text{Apomorphine.}},$$

which differs in a remarkable manner from morphine, born in its chemical and physiological actions, being soluble in alcohol, ether, and chloroform, whereas morphine is nearly insoluble, and acting as the most powerful emetic known, one-tenth of a grain producing vomiting in less than ten minutes. Codeine, which only differs from morphine by CH_2 also yields apomorphine on treatment, at a high temperature with hydrochloric acid, methyl chloride being at the same time eliminated.

An important application of the dehydrating and carbon condensing power of zinc chloride, long known in its action on alcohol to produce ether, has been made by Kekulé in the reduplication of aldehyde to form croton aldehyde with loss of water—

$$2(C_2H_4O) - H_2O = C_4H_6O.$$

This croton aldehyde is also probably formed as an intermediate product in the manufacture of chloral from aldehyde, and gives rise to the formation of croton chloral, $C_4H_3Cl_3O$.

The discovery of the sedative properties of chloral hydrate by Liebreich marks an era in medical chemistry second only to the discovery of the anæsthetic properties of chloroform. Chloral not only combines with water to form a solid hydrate but also forms solid alcoholates; but these bodies appear to possess quite different medicinal properties from the hydrate, and it is important that no alcoholate should be present in the official preparation.

The chemistry of colouring matters has lately received an enormous impetus in the practical working of the brilliant discovery of the production of artificial alizarine, the colouring matter of madder, by Messrs. Graebe and Liebermann. This discovery, announced at our last meeting, is of the highest importance—whether we regard its scientific interest or its practical and commercial value—and it differs from all the former results which have been brought about by the application of science to the production of colouring matter, inasmuch as this has reference to the artificial production of a natural vegetable colouring substance, which has been used as a dye from time immemorial, and which is still employed in enormous quantities for the production of the pink, purple, and black colours which are seen everywhere on printed calicoes. During the past year much progress has been made in the practical working of the processes by which this colouring matter is obtained from the hydrocarbon anthracene contained in coal tar, and new and more economical plans for effecting the transformation have been independently proposed by Perkin and Caro, and Schorlemmer and Dale. The theoretical investigation of the reaction—and especially of the nature of some other peculiar products formed in addition to alizarine, which render the artificial colouring matter different from natural alizarine—has been carried out by Mr. Perkin, and especially by Dr. Schunck. As we are promised papers on this subject from both these gentlemen, I need not at present enter further into these interesting questions.

The surest proof of perfection in a manufacture is the degree in which the waste products are utilised, and in which the processes are made continuous. One by one the imperfections of the original discovery are made to disappear, and the products which were wasted become sources of profit, whilst in many cases their utilisation alone renders possible the continuance of the manufacture in the midst of a rapid increasing district. The section will have the opportunity of inspecting the practical working of at least two of the most valuable of these new processes which have lately been introduced into our most important chemical manufacture—that of alkali. The first of these has been at work for some time, it is that of the recovery of sulphur from the vat waste, that *bête noir* of the alkali makers and of their neighbours. Dr. Mond has now, I believe, satisfactorily solved the difficult problem of economically regaining the sulphur by oxidising the insoluble monosulphide of calcium in the lixiviating vat itself to the soluble hyposulphite, and decomposing this by hydrochloric acid when all the sulphur is deposited as a white powder. The second of these discoveries relates to the recovery or regeneration of the black oxide of manganese used for the evolution of chlorine in the manufacture of bleaching powder. This subject has long attracted the attention of chemists, and a feasible, though somewhat costly, process—that of Dunlop—has been at work for some time at Messrs. Tennant's work at St. Rollox. During the last year a very beautifully simple and economical process proposed by Mr. Weldon, and first successfully carried out in a practical scale at Messrs. Gamble's work at St. Helen's, has quickly obtained recognition, and is now worked by more than thirty-seven firms throughout the kingdom. The principle upon which this process depends was explained by Mr. Weldon at the Exeter meeting. It depends on the fact that although when alone the oxides of manganese cannot be oxidised by air and steam under the ordinary pressure to the state of bioxide, yet that this is possible when one molecule of lime is present to each molecule of oxide of manganese. The manganous oxide is precipitated from the still liquors with the above excess of lime, and by the action of steam and air on this, a black powder, consisting of a compound of manganese, dioxide and lime, MnO_2CaO, or calcium manganite, is formed. This, of course, is capable of again generating chlorine on addition of hydrochlorine acid and thus the chlorine process is made continuous with a working loss of only $2\frac{1}{2}$ per cent.

of manganese. The section will have the advantage of seeing Mond's process at work at Messrs. Hutchinson's, and Weldon's process at Messrs. Gaskell, Deacon, and Co., at Widnes. A third process, which may possibly still further revolutionise the manufacture of bleaching powder, is the direct production of chlorine from hydrochloric acid without the use of manganese at all. In presence of oxygen and of certain metallic oxides, such as oxide of copper, hydrochloric acid gas parts at a red heat with all its hydrogen, water and chlorine being formed. This interesting reaction is employed by its discoverer, Mr. Deacon, for the direct manufacture of bleaching powder from the gases issuing directly from the salt-cake furnace. Air is admitted together with hydrochloric acid gas, and with copper salt. The oxide of copper acts as by contact and remains unaltered, whilst the chloride, watery vapour, and excess of air pass at once into the lime chamber. There are many practical difficulties in working this process, some of hich have still to be overcome, but I believe we shall hear from Mr. Deacon that, notwithstanding this drawback, he has accomplished his end of making good bleaching powder by this process.

ON THE APPLICATION OF THE CENTRE RAIL SYSTEM TO A RAILWAY IN BRAZIL, AND TO OTHER MOUNTAIN LINES; ALSO ON THE ADVANTAGES OF NARROW GAUGE RAILWAYS.

By Mr. J. B. Fell, C.E.

Since the opening of the Mont Cenis Railway in June, 1868, other mountain lines on the centre rail system have been under consideration in different parts of the world. One of these lines now being constructed is in Brazil. It commences at the terminus of the Canta Gallo railway, crosses the Serra at an elevation of 3,000ft. above the Canta Gallo line, and terminates at the town of Novo Friburgo, a distance of twenty miles. In some of its principal features this resembles the summit line of the Mont Cenis, the gradients for the passage of the Serra over a distance of ten miles, being principally from 1 in 20 to 1 in 12, and the curves by which the line winds round the spurs or counterforts of the mountain being for a considerable portion of it, from 40 to 100 metres radius. The narrow gauge of 1·10 metres has also been adopted. In other features, however, there is an important difference between these two centre-rail lines. The concession for the Mont Cenis was but temporary, terminating at the completion of the great tunnel, and the railway is laid on the existing public road, whereas the Canta Gallo line will be permanent, and the works will be so constructed as to be especially adapted to its requirements. It will not have to contend with the difficulties of an Alpine climate, and, profiting by the experience of two years' working on the Mont Cenis, it will have the advantage of important improvements which have been made in the engines, carriages, and permanent way during that period. Consequently, the Canta Gallo and other similar lines, now being or about to be commenced, have the interest of marking a development of the capabilities and advantages of the centre rail system, as applied to the construction and working of mountain railways. It may be useful here to record what has already been accomplished in the task of carrying railways over mountain passes, hitherto inaccessible to the locomotive, and of giving it the power of safely carrying trains of passengers and goods upon gradients and curves which would previously have been considered most perilous, and, indeed, impracticable. The Mont Cenis Railway has now been open for traffic two years and three months, and during that period the trains have run a distance of more than 200,000 miles, have carried between France and Italy over 100,000 passengers without injury to any one of them, and has effected the transport of a considerable quantity of merchandise. Since the month of September last, it has carried the accelerated Indian mail, and by the service thus established the delivery of the Indian mail in London *viâ* Marseilles has been anticipated by the Brindisi and Mont Cenis route by about thirty hours. The ordinary mails between France and Italy have been carried by the Mont Cenis Railway since its opening, and one night of travelling has been cut off the journey between Paris and Turin. Although the Mont Cenis Railway cannot be taken as a type of the best or most approved application of the centre rail system, it has had the effect of proving its mechanical practicability and safety when put to the most crucial test to which any new principle could be submitted. There have been mechanical defects in the construction of the engines which have added unnecessarily to the cost of traction, and these defects can and will be removed in the engines about to be built for the Brazilian and for future centre rail lines. The cost of traction, as might be expected under the circumstances, has hitherto been high—about 3f. per train kilometre; but there can be no doubt that with improved engines and good management the cost of traction may be reduced to 1f. 50c. per train kilometre. The Semmering incline in Austria furnishes an example of the economy that may be effected by improved machinery and management, the cost of locomotive power having been reduced from 2·85 francs in 1860 to 2·15 francs in 1863, 1·70 franc in 1865, and 1·49 franc in 1866. In the four new engines last built for the Mont Cenis line a considerable saving has been made in the cost of repairs by using four cylinders in place of two. By this arrangement the inside and outside mechanisms are disconnected, and any contention between the two is avoided. The adhesion, however, is equal to the two cylinder engines, and the power is transmitted from the inside cylinders to the vertical axles by means of a train of toothed wheels. In the new engines for the Canta Gallo line it is proposed to dispense with the toothed wheels and substitute for them a system of direct driving by connecting rods. The power of adhesion will also be considerably increased. These new engines will have the advantage of being able to run at a speed of from 20 to 30 miles an hour upon the ordinary gradients of the line, and of taking their loads up the mountain section at a diminished speed of from eight to ten miles an hour. In an economic point of view the result of the application of the centre rail system to the Canta Gallo Railway will be as follows:—The cost of construction, assuming it to be as estimated, about £300,000, would be at least doubled if made on gradients upon which ordinary engines could work. In this case the costs of traction and maintenance for a centre rail line will not be greater than for a line with ordinary gradients passing over the same country. The clear saving, therefore, effected by employing the centre rail system is at least £300,000, and the construction of a valuable line of railway has been rendered possible which would otherwise have been commercially and financially impracticable. A somewhat similar line of railway is under consideration by the Indian Government, from the port of Karwar to Hooblee, in the Southern Mahratta country, both by way of the Arbyle and the Kyga Ghats. The distance is ninety miles, and it is proposed to employ the centre rail for a length of about ton miles upon gradients of 1 in 20 for the passage of the Ghat, by which a saving would be effected of about £500,000. The cost at the present time of the transport of cotton and other produce over the ninety miles is stated to be £235,000 per annum, and there is in addition the disadvantage of not being able to convey the whole crop to the port of shipment before the rainy season sets in; a large portion of it has consequently to be housed and kept until that is over. Negotiations are going on with the Government local authorities and people interested for the construction of centre rail lines in Italy from the Adriatic to Maserata and crossing the Appenines to Foligno from Florence to Faenza, and for three branch railways in the Neapolitan States; in France, from Chambery to St. André du Gaz and Lyons direct, crossing the Col de l'Epine; in Switzerland, for the passage of the Simplon; and in Spain, for lines from Leon to Corunna and Gion. The concession for the Mont Cenis Railway expires on the opening of the tunnel line, and when that period arrives it has been proposed to remove it to one of the neighbouring mountain passes where it would have a permanent life. At the time the concessions were granted it was considered that the line would be worked for ten, or at least seven, years; the progress of the great tunnel has, however, been so much accelerated that it is stated the tunnel line may possibly be opened for traffic by the end of 1871. In that case, and taking into account the difficulties of all kinds with which the enterprise has had to contend, the Mont Cenis Railway can only be regarded as an experimental line, and the pioneer of a system destined to confer the benefits of a cheap and safe communication between many countries separated by mountain ranges hitherto impassable by railways and locomotive engines, and the promoters must look to the future for the reward of their labours and the anxieties of the past. Drawings were exhibited of a new system of narrow gauge or suspension railways, an example of which has recently been constructed as a branch line for carrying iron ore from the Parkhouse Mines to the Furness Railway in North Lancashire. The gauge of this line is eight inches, and the length about one mile. It is carried at various elevations from three to 20 feet over an undulating country, passing over the fences, roads, and watercourses without requiring the construction of earthworks or masonry. The structure consists of a double beam of wood, supported at intervals on a single row of pillars. The narrow gauge is practically made equivalent to a broader one by the steadying power of guide rails fixed on the sides of the beam and below the carrying rails. The bodies of the waggons are suspended from the axles, and by this means the centre of gravity is brought low. They are also furnished with horizontal wheels which run upon the guide bars, and thus maintain the equilibrium of the carriages, and render it almost impossible for them to leave the rails. The Park-House line will have a traffic of 50,000 tons per annum. The cost has been £1,000 per mile without stations or rolling stock. It was worked by a stationary engine and endless wire rope. The saving effected in the cost of transport will be at least 6d. per ton upon the distance of one mile. In Switzerland application has been made to the Government of the Canton Vaud for a passenger line on this principle, from the town of Lausanne to the Lake of Geneva. Plans have also been laid before the War Office for accelerating military transport in foreign countries and before the Governor-General of India for the construction of cheap branches from the trunk lines in that country. The gauge of these railways may be from six to 18 inches. They may be made of wood or iron, or of the two combined, and may be worked by either stationary engines or by locomotives of a form specially designed for the purpose. They have the advantages of being economical in both construction and working, they occupy but little land, and cause no severance, they may be erected with great rapidity, and being portable may be removed when no longer required and re-erected in another locality. Before the war commenced an offer was made to the French Government to construct one of these portable railways to supply their army with from 1,000 to 3,000 tons of ammunition and provisions per day. The work would have been undertaken by a gentleman in Paris, who with a force of 2,500 men, would have constructed from four to five miles of railway per day, following the advance of the army into Germany. The result has, however, shown how little such a provision was needed.

RECENT VISIT TO THE GREAT TUNNEL THROUGH THE ALPS.

By Professor Anstead.

The tunnel, as Professor Anstead reminded the audience, will perforate the crest of the main chains of the Alps, nearly midway between Mont Tabor and Mont Cenis, passing nearly under the summit of Mont Frejus. The operations of the tunnel involves a direct cut through a series of rocks on a line whose depth below the surface was almost at once very considerable. Owing to the form of the ground and the rise of the mountain, the depth was 2,000 feet at each end after 2,000 feet of tunnelling. From this point, however, the depth increased very little from each end for a long distance. In the middle of the tunnel the depth below the surface is 5,400 feet, while the deepest borings for such works as mines and wells do not exceed 3,000 feet. The works have been carried on throughout with some regard to the great physical questions involved. Among these the temperature at various distances and depths beneath the surface was not the least important. Instructions were given to bore a large hole laterally into the rock for a distance of about 10 feet, at intervals of 500 metres, and determine the temperature of the rock by thermometers provided for the purpose. On the northern side this important experiment had been carelessly executed, but on the south side, especially towards the centre, some good observations had been made, and the result was somewhat startling. The last observation made at the time of his visit was at 6,200 metres (20,342 feet) from the south end, at a depth of more than 5,000 feet. The result was 28° C. = 80½° F. This would reduce the increment to a degree Fahrenheit in more than 100 feet, the general increase being observed in mines to average a degree in about 60 feet. Here again, however, there was still something wanting, the mean annual temperature of the surface not being accurately known, and the depth from the surface of the stratum of permanent temperature never having been determined. With reference to the progress of the work of tunnelling, the Professor stated that on the 31st of last month there remained less than 2,000 feet out of 40,000 feet to pierce, and as the present rate of progress is about 500 feet per month, it may be expected that the communication will be complete by the commencement of the ensuing year.

MECHANICAL SECTION G.

Address of the President, Mr. Charles B. Vignoles, C.E., F.R.S.

Gentlemen,—My original intention was not to have troubled the section with any preparatory observations, as we have quite enough to do, and I must, in my address, have contented myself with enumerating what are the probable elements of discussion. But when I recollect of what day this is the anniversary, and how much Liverpool had to do with that occasion and how much I was myself personally connected with it, I have been unable to refrain from endeavouring to recall to the memory of Liverpool, and more particularly to the members of the Mechanical Section, the circumstances which occurred forty years ago. It is exactly forty years to-day that the Liverpool and Manchester Railway was opened, and it was entirely owing to the high spirit and zeal of the Liverpool merchants that that great act was accomplished. I have in another place and on another occasion alluded briefly to the history of it, but the summary may be said to be this, that the ways and means of communication were so completely crippled forty years ago, that the trade of Liverpool would have become, and was becoming paralysed; and it was the creation of cheaper means of communication by the railway in which Liverpool took the lead; and it was particularly to one of the distinguished citizens of Liverpool (Mr. Henry Booth), who was the original secretary of the company, that much of that was due, not only on account of the energy he brought into the committee, but for his scientific knowledge, which contributed most materially to the improvement of the engine which is now doing such wonders at home and abroad. I hope the people of Liverpool will excuse me when I remark that I think they have not been sufficiently grateful to the memory of Henry Booth, but had suffered his name to be almost forgotten. I was very glad to have been present at a meeting in Liverpool about six months ago, at which a subscription was entered into for the purpose of raising a statue to Henry Booth, the necessary fund for which is nearly obtained, and only requires for its completion a little help from the Liverpool people, who have benefited so greatly by what Henry Booth has done. I hope that on an early occasion I may be present at the inauguration of the statue in the hall where yesterday I had the honour of attending the inauguration of the statue of Gladstone. It appears to me that Liverpool is peculiarly a place to be chosen for the meeting of the British Association. The British Association and railway system may be said to have had their birth at the same time. This is the fortieth anniversary of the meeting of the British Association and it is the fortieth anniversary of the opening of the Liverpool and Manchester Railway. There is, therefore, a very just and legitimate connection between us. I feel peculiarly flattered and honoured by the Council of the British Association having invited me to preside over this section, inasmuch as I had much to do with the laying out of the original Liverpool and Manchester Railway, and I resided there for several years, far back when my children were born, and in my earliest days of social, and family, and professional connection. I spent some of my happiest days in Liverpool some forty years ago, and I cannot express the gratification that I feel in presiding here in this town, which has grown as wonderfully as the British Association itself in importance and in interest.

The subjects of most interest which are likely to be brought before the section on this occasion may be divided into the following heads:—The subjects of steam boilers, and all the advantages and disadvantages connected with them; the sewering of the town of Liverpool; and, as regards what I may call the military aspects of affairs, we have the question of improved ordnance; matters respecting shipbuilding and the stability of ships; and improvements in rifles, and musketry, and in various other matters connected with military affairs. Speaking of the subject, I take the opportunity of referring to remarks that have been made from time to time in the papers as to efficiency or non-efficiency of the military services of England, and I think I shall be disabusing the minds of many who have supposed that this country is not prepared or that the Government have been unaware of the necessity of creating the best means of communication, in the event of invasion or war, by stating that for several years the military department of the Horse Guards and the chief engineers of the country have been in constant communication, and have formed deliberate arrangements, by which in the event of any casualty occurring, such as an invasion of the country, within forty-eight hours the whole of the military forces of the country—100,000 men, if we had them at our disposal—might be brought to any one point of assault. With respect to the landing of an enemy, let me quote from Mr. Kinglake's "History of the Invasion of the Crimea," to show how well we should be prepared if we could bring 100,000 men, which we could, within eight and forty hours on any part of the coast, and to ascertain what an enemy could do in the event of landing there. Mr. Kinglake, speaking of the landing in the Crimea, says that,—"Under circumstances of weather which were wholly favourable, and with the advantage of encountering no opposition from the enemy, a force of 26,000 infantry, 1,000 cavalry, and sixty guns were landed in the course of five September days." This is to say, not more than five or six thousand men could be landed under the most favourable circumstances in one day. Mr. Kinglake goes on to observe that, "The operation was conducted with almost faultless skill, and was proceeded with in a way that was thought to be right for landing a force in the face of an enemy, and though the surf was somewhat heavy, not a man was lost." Therefore, under the most favourable circumstances, landing under the guns of the fleet, with everything conducted with the most scientific and perfect order, and without opposition from the enemy, it took five days to land somewhat less than 30,000 men. This is a question that I personally treated at the request of the Government, and I have demonstrated in the most complete manner, that within the short notice of eight and forty hours, or within twelve hours after an alarm has been given, the various rolling stocks of the railways may be withdrawn from the face of the enemy, and the whole military resources of the country poured down upon one point. I think possibly that the knowledge of that fact may afford consolation to those, whether old soldiers or old women, who are fond of crying out about the want of preparation. I hope you will excuse a little personal vanity of mine, when I say that, forty-one years ago in this town of Liverpool I stated that the result of the railways would be to enable the Government to do that which I have now endeavoured to show can be done, namely, bring the whole forces of the country to bear upon any invaded point, and also that on the Continent those events were likely to occur which have happened within the past few months..

But to revert to the subject of our immediate meeting. As I have already stated, among the subjects for discussion are steam boilers, sewerage, improved ordnance, and shipbuilding, and there will also be the Martini rifle and the stability of ships. On the last question, that of the stability of ships, I hope on Tuesday next to put before you some important papers, and we shall also have the advantage of the presence of some of the most distinguished men in the country who will give their opinions upon that subject, which is just now one of special interest, bearing as it does upon the unfortunate accident which has lately occurred. The mind of the naval and scientific world is directed at this moment to the solution of the question to what cause is to be attributed that accident which all so much deplore. (Hear, hear.) No one can deplore more than I do the loss of the gallant commander of the Captain, who was one of my oldest friends whom I have known from his birth, and who had long promised to make the name of Hugh Burgoyne as distinguished in naval annals as is that of his distinguished father, Sir John Burgoyne, in military science. Gentleman, I will not detain you longer. I should not have occupied your time thus far had not the intimate connection of Liverpool with the origin of the railway system, and of the British Association, tempted me to wander, I am afraid rather discursively, into the question at which I have glanced.

MEETING OF THE IRON AND STEEL INSTITUTE IN SOUTH WALES.

ON THE EFFICIENCY AND DURABILITY OF PLAIN CYLINDRICAL BOILERS.

By Mr. Jeremiah Head, Middlesbrough.

The object of the paper I have the honour to bring under your notice is to call attention to certain advantages and certain disadvantages attending the use of boilers belonging to the class known as plain cylindrical or egg-ended; to investigate the cause and extent of their defects, and, if possible, to point out satisfactory remedies.

Anticipating an objection likely to be advanced by some, viz., that the plain cylindrical type is an antiquated one, and ought to be superseded entirely, I would urge that it is still adhered to in preference to others in new undertakings under the direction of engineers of the highest standing. But were this not the case the large number of these boilers in actual operation gives importance to any plan whereby greater efficiency and durability can be secured. In order that no doubt may remain on this point the records of the various steam boiler insurance companies have been consulted. It is assumed that the proportion of plain cylindrical to other boilers on their books is a fair criterion of the general proportion throughout the country.

Here follows the result, which has only been arrived at through the kind and courteous co-operation of the chief engineers of the various companies:— The Boiler Insurance and Steam Power Company, whose head-quarters are at 67, King-street, Manchester, have 16 per cent. of all their boilers belonging to the plain cylindrical type.

The Manchester Steam Users' Association have 12½ per cent. of the same.

The Midland Steam Boiler Inspection and Assurance Company show that in their Midland district 66 per cent., and in their Northern district 69 per cent. of the boilers upon their books are of the class under consideration.

The total number of boilers insured in these associations is 17,825, and the total number of plain cylindrical ones 4,052. These numbers will be found to give 22·7 per cent. as the general average proportion of plain cylindrical to the total number of boilers insured.

Two conclusions may here be drawn:—First, that the number of plain cylindrical boilers now in use is sufficient to entitle them to special consideration; secondly, that the favour with which they are regarded differs materially in different localities.

Let us now investigate the usefulness in proportion to the cost of these boilers, in order to understand accurately our position before judging of their general value. Having regard to the diversity which is certain to exist in the dimensions and other circumstances of various examples, we shall find it answer our purpose best to confine ourselves to the consideration of one particular case. From such results as we may arrive at, deductions may afterwards be made, subject to modification, according to varying circumstances.

The plain cylindrical boiler illustrated (Fig. 1) is an ordinary one, as used in the coal and iron districts of the north of England. It is 45ft. long, and 4ft. diameter. (For the utilisation of the heat produced by the combustion of the waste gases from blast furnaces, boilers as long as 60ft., or even 80ft., by 4ft. 6in. diameter, are frequent). The plates are ⅜in. thick throughout. It weighs, exclusive of mountings, except such as are riveted to the boiler, about 5¼ tons. It is set in brickwork, as shown (Fig. 2), one "flash" flue extending from end to end, and embracing one-half of the entire surface of the boiler. It is hung upon three cast iron bearers by means of nine suspension rods, secured to T irons riveted to the boiler. The suspension rods have double eyes at their lower, and adjustable nuts resting upon the bearers at their upper ends. In this way the heating surface is not interfered with by the supports, and the latter are preserved from contact with high heats. The fittings consist of the following, viz.:—Glass water gauge, float gauge, two safety valves, steam valve, feed valve, and sludge cock. The steam, feed, and sludge valves are directly connected with the same transverse mains as the similar fittings of other boilers in the same range. The sludge cock is fixed to the end of the boiler farthest from the grate, and a downward inclination in that direction assists in securing the complete removal of water and mud when required.

Such a boiler is obviously as simple as could possibly be constructed. No great bending or flanging tests are applied to the plates, and therefore an ordinary quality and ordinary workmanship are alone necessary.

The diameter being moderate, a high pressure may safely be maintained without the use of thick plates, and without the expense of double riveting and drilled holes. The brickwork is simple and easily maintained, and the boiler is readily examined for cleaning or repairs, both inside and out.

Should the water be impure this latter advantage becomes very prominent. Again, the risk of overheating for lack of water is much less than with internally-fired boilers. The great quantity of water contained undisplaced by internal flues or tubes is a security against rapid change of level; and even should such change take place, it must amount to something very considerable before any portion of the heating surface in the locality of excessive heat would be laid bare. Indeed, it would not be easy to cause a plain cylindrical boiler to explode merely for lack of water.

So much for simplicity of construction and ease of examination. Next as regards cost. This again varies with the locality. Taking the prices at present ruling in the Cleveland district (July, 1870), plain cylindrical boilers, including such mountings only as are riveted to the boiler, of best material and workmanship for the purpose, cost £18 10s. per ton delivered. This, multiplied by 5¼ tons, gives £97 2s. 6d. as the price of the boiler.

Next, as to power of evaporation.

The total grate surface is 24 square feet; gross heating surface, 283 square feet. The boiler consumes 420lb. of coal per hour, and evaporates 50 cubic feet from 162 deg., equal to 7·7lb. of boiling water per pound of good South Durham coal. This result has been obtained by a carefully conducted experiment made by the writer, and lasting 130 hours. The evaporation was arrived at by inserting a Siemens water gauge in the feed pipe, and allowing for the difference of temperature between 162 deg. and 212 deg.

Let us compare this duty with that of internally-fired boilers as now made, having two flues and cross tubes. To evaporate the same quantity of boiling water per hour from a single boiler the necessary dimensions would be as follows, viz.:—Length, 28ft.; diameter, 6ft. 6in.; two flues, each 2ft. 6in. diameter; thickness of shell plates, ½in., and of flue plates ⅜in.; grate surface, 25 square feet; gross heating surface outside and inside, 550 square feet; weight, 11 tons; cost, excluding fittings not riveted to boiler —at £27 10s. per ton—£290. This price per ton is actually being paid for first-class boiler work of the kind described, delivered in Middlesbrough, and more is sometimes quoted. Such a boiler is an example of the best arrangement for the purpose of the internally-fired class.

With regard to economic power, let us take the average of four experiments made by the Government upon such a boiler, with Welsh, Newcastle, Scotch, and Lancashire coal.

The result is 8·4lb. of boiling water evaporated per hour per pound of coal. The experiments are taken from Box's "Practical Treatise on Heat," page 40. It is not stated whether, in the Government experiments, the flues were furnished with cross tubes, but whether or no is considered immaterial. There is no doubt the boilers would have external flues, and the experiments made in 1868, at Wigan, by Dr. Richardson and Mr. L. E. Fletcher, proved conclusively that internally-fired boilers, with external flues, did not raise more steam by the addition of cross tubes. The latter seemed to act where there is abundant heating surface, merely in the way of abstracting the heat at an earlier stage, and leaving less to be afterwards absorbed by the external shell.

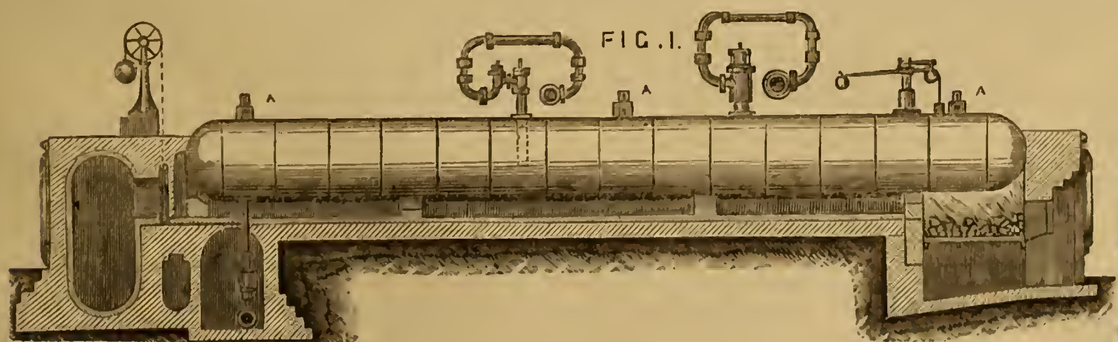


FIG. 1.

FIG. 2.

To summarise briefly: Supposing we had determined to obtain our evaporation of 50 cub. ft. per hour, by means of an internally-fired boiler instead of one as illustrated.

The first cost would be £290. instead of £97 2s. 6d., or nearly threefold.

The saving in fuel to compensate for this extra expenditure would be as the difference between 7·7 and 8·4 is to the latter number, or about 9 per cent.

The extra cost of interest, maintenance, and depreciation would surely balance this advantage in economy. How is it, then, that many are prepared to substitute the more complex, and, apparently so far as we have gone, the more dangerous appliance, at nearly three times the outlay, unless there is some reason for such preference not yet considered by us?

We will now investigate the principal defect of plain cylindrical boilers, a defect which, it is believed, lies at the root of most of the feeling which is, perhaps properly, entertained against them in some localities. It may be expressed in homely language in very few words:—*They are liable to break their backs.*

Fig. 1 has been selected as a type illustrating a boiler recently laid off for repairs by reason of fractures, and for the second time within six years.

It is to be observed that the fractures are all in a transverse direction at the bottom side, and extending upwards towards the top of the boiler. They all pass through the line of rivet holes of either an inside or outside lap. They are not found at that part of the boiler exposed to the fiercest heat. Although by means of a peep hole in the main flue beyond the damper, the flames were observed to extend the full length of the boiler immediately after firing, they usually appeared only as illustrated. A minute examination of the bottom, after the boiler was laid off and turned up to the light, showed that the fins of the rivets, the marks of the caulking tools, and the edges of the plates, were, except in the region of constant flame, as sharp and fresh as ever. The feed being introduced at nearly boiling temperature, and in a direction parallel with the bottom, could hardly be supposed to have any influence, especially when the relative magnitude and position of the cracks in regard to it is considered.

There did not appear to be any great difference in quality between the top and bottom plates. Small pieces were cut from each locality and broken cold, but the quality revealed was fully equal to the average used for the purpose.

How then shall we account for these fractures? Why should they be always at the bottom and in a transverse direction? Is not the action of heavy tensile strains indicated, strains which could not exist if the weight of the boiler, and the water inside, were properly distributed over the several bearers? Is it possible that some of these supports are occasionally not acting, and so throwing the weight they ought to bear upon the others? Let us see.

Passing over the tops of a range of boilers when at work, the writer has often observed that the nuts of the suspension rods at one end of the boilers were slack, and might be turned by the hand. This led to the reflection that that end of each boiler must be resting on the middle bearer alone. A tendency to raise the other end would result, and so almost the whole weight, say, including water, sixteen tons, would fall to the share of one bearer.

When a boiler ceased work, and the water within cooled, the nuts of the end suspension rods became fast, and could no longer be moved by hand, while the nuts of the middle bearer exhibited signs of lifting.

The boiler thus appeared to have been at one time supported from a single point, with 22½ft. of length, and eight tons weight either way; and at another time to have been stretched between two supports 38ft. apart, and having, say, fourteen tons intervening. Such an operation, especially if often repeated, would obviously suffice to destroy structures of the nature we have under consideration.

The alternate rising and sinking of the ends of a boiler, according as it is under steam or not, is produced by the expansion and contraction of the boiler shell. It is obvious that the upper part must always be, taking the mean temperature of the plates, cooler than the steam within; otherwise the steam would not give up its heat to the iron, nor the iron to the air, or whatever substance was in contact with it. We know that however well a boiler is protected, some heat is lost through the covering.

Again, the under surface must, when at work, always be, still taking the mean temperature of the plates, hotter than the steam and water within, otherwise no heat would pass into the water, and no steam would be generated. Hence, assuming the steam and water to be 310 deg. Fah., corresponding to a pressure of 50lb. per square inch, it follows that the top plates must be cooler, and the bottom plates hotter than 310 deg. How much the top plates are cooler must depend on the efficiency and thickness of the covering. How much the bottom plates are hotter than the water within is not very easy to determine. But let us endeavour to estimate it. The temperature of the flame in the furnace is at times sufficient to melt grey cast iron, which, according to Professor Roscoe, is 2,192 deg. Fah. The average temperature of the gases at the damper as ascertained by experiment, was 750 deg.

The mean of these two, viz., 1,470 deg., gives the average temperature of the gases in contact with the outer skin of the bottom plates. The plates being then in contact with gases at 1,470 deg. on their outer surface, and a liquid at 310 deg. within, might be supposed to occupy an average temperature equal to the mean between these two, which is 890 deg. This is about 80 deg. lower than the lowest temperature visibly red in the dark.

Supposing the top plates were well protected and maintained at an average of 300 deg., or 10 deg. cooler than the steam, a difference of 500 deg. would then exist between the top and bottom plates. The expansion due to this difference is 1⅞in. in a length, equal to the boiler illustrated. In other words, if our reasonings are correct, the bottom of the boiler when at work tries to elongate itself nearly 2in. in excess of the top. This corresponds to a rise at the end bearers of 3in. above the level. A lifting to this extent does not, however, in practice take place in the length shown. The boiler meets with no small resistance in its attempts to assume a new form, partly from the weight of the ends and the water within, and partly from its own rigidity of structure. But it does rise visibly and tangibly, and the condition of the bottom plates when hot must be one of constant severe compression.

Let us now inquire into the state of matters at the end of the week, when the fire is withdrawn, and the steam blown off. The bottom plates are then evidently in contact with water at 212 deg., and must at once assume that temperature also. Do the ends of the boiler then return to their original seats? Have they taken a permanent upward set? Or does the bottom of the boiler, now clear of flame, and in contact with boiling water only, endeavour to contract to a length less than its original one, drawing together the ends with a downward curve, so as to bear hard upon the end supports, and cause the top plates to arch up clear of the middle support?

There being considerable doubt as to the behaviour of iron under these circumstances, it was thought desirable by the writer to make an experiment. A gauge was made of ⅜in. boiler plate, having an opening between two projections, this opening being exactly 1ft. in length. Five strips of similar boiler plate were accurately fitted to the gauge, so that they would just pass between the projections, if assisted by slight pressure, but would not fall through by their own weight. The strips of iron were then carefully heated one by one, by placing them within a red hot tube of iron. As soon as they began to turn blue, and somewhat before they were likely to become visibly red, they were withdrawn and slacked in boiling water. This was intended to show the action of the bottom of a boiler when at work, and say at 890 deg., and then, by the withdrawal of the fire and blowing off the steam, quickly reduced by contact with the water down to 212 deg.

It was desired to ascertain whether the iron would permanently extend, contract, or remain unaltered in length. One of the pieces described was subjected to the process twenty times, a second forty, a third sixty, a fourth eighty, and a fifth 100 times. The pieces and the original gauge will be produced for inspection at the discussion. None of the pieces were heated sufficiently to become in the slightest degree scaled or oxydised. The effect of the alternate heating and slacking was not at first perceptible; but after several repetitions it became evident that a slight permanent contraction was taking place each time. So far as the experiment was carried, viz., up to 100 heatings and coolings, the contraction appeared to be constant and regular. After the hundredth operation, representing the condition of the bottom of a boiler after being cooled down weekly for two years, the total permanent contraction was No. 15 Birmingham wire gauge, or one-fourteenth of an inch. The difference in length of the bottom of a 45ft. boiler at this rate amounts to 3¼in. It seems, then, that after a lapse of time as mentioned the bottom of a boiler would, when not at work, exert itself to become 3¼in. shorter than the top. This would subject all the bottom plates and joints to severe tension.

Taking this into consideration in connection with the expansive action previously described, it appears that a new boiler would lift at the ends when at work a maximum amount. That gradually as it becomes older and passed through successive coolings, the bottom contracting a little each time, it would come to lift the ends less and less, until at last they would not lift at all; but the bottom when at work would at most expand to its original length. But it is evident that, under such circumstances, the contraction at the end of each week would become stronger and stronger, until at last it must either arch the boiler clear of its middle support, or the latter must break its back through the weakest seam. Occasionally relief may be afforded by a simultaneous loosening of several of the bottom seams, followed by a telescopic action and leakage.

But are plain cylindrical the only boilers which break their backs and lift at the ends? Certainly not. All externally-fired boilers, whether also internally-fired or not, exhibit the same tendencies. But inasmuch as it is the custom to make plain cylindrical boilers longer, in order to obtain ample heating surface, and smaller in diameter than other kinds, the defects common to all become more glaring and destructive in their case.

But is it not possible to prevent this great evil, and so obtain the advantages of the plain cylindrical boiler without its defects?

Happily it is possible, and by a method which is extremely simple. It has been already in practical operation six months, and, with complete success, applied to a boiler repaired after breaking its back.

It consists in so arranging the supports of the boiler that they follow it through each change of form without materially increasing or relaxing their hold. The cast iron bearers are retained as before, also the suspension rods, but the latter are lengthened; and the nuts upon them, instead of resting upon the bearer, rest upon a volute spring encircling the suspension rod and seated upon the bearer. The boiler illustrated in Figs. 1 and 2, rests upon nine volute springs, each carrying 1¾ tons, with a compression of 1⅞in. The boiler is entirely free of other support, and can assume any new form possible, without being subjected to more than a very slight alteration in the strains upon its various parts. Except upon yielding supports it is quite impossible to support long structures subject to great alternations of heat without ultimate damage. Only two difficulties occurred in carrying out this plan in practice. The first was, how to prevent the breakage of the various connections with the mains. Inasmuch as the boiler was now free to rise and fall, and change its form according to circumstances, the steam feed and sludge branches connected with their respective mains might be expected to snap off. But this difficulty was met by simply adopting circuitous instead of direct connections. Elasticity to any requisite amount may thus be secured.

The second difficulty was this. It is obvious that if 1¾ tons each were resting upon the volute springs, each one must be exerting constantly an upward force to that extent. But at the end of the week, when the water constituting two-thirds of the whole weight was allowed to run off, the springs would certainly lift the boiler so lightened out of its position to a proportionate extent. The boiler lifted, say two-thirds of 1⅞in., or about 1¼in., the brick-work would be loosened, and leaky flues would be the result. But this danger was overcome by inserting between each bearer and the top of the boiler, and fixed to the latter, two adjustable set bolts, which we call *gags* (Fig. 5.) These permit a certain rise, and then come into contact with the bearer, stopping further lifting by the spring. The end gags should be adjusted when the boiler is at work, and the middle one when cold, but not empty. If under these circumstances they are set just clear of the bearers they will not prevent the necessary changes of form from expansion and contraction, but only any ill effects to the brickwork from loss of water. The boiler (Figs. 1 and 2), which has been hung upon springs, and has been in operation at Middlesbrough since the beginning of March, rises at the ends and sinks in the middle when at work, and just the reverse when the fire is withdrawn and the steam blown off. The mean variation in height at the end bearers, as compared with the middle, is ⅜in. The nuts of the suspension rods are, of course, always tight. No disarrangement of brickwork is perceptible, and the boiler does its work well in every respect. The cost of extra material and fitting involved by the alteration of the boiler under consideration is evidently insignificant, and the method is just as applicable to existing boilers as to new ones. The longer the boiler the more necessary it becomes; indeed, much longer boilers than hitherto made might be safely used, provided they were hung upon springs. The alteration becomes of especial importance where the heat is derived from the combustion of a continuous stream of gas, as in the case of boilers attached to blast furnaces. Assuming the compression of the spring to be directly proportionate to the load upon it, then every sixteenth of an inch variation would correspond to a variation of load equal to one sixteenth of a ton, or 1¼ cwt. So that with the deflection described, and supposing each spring to carry an equal share of the weight, the middle springs would have 3¾ cwt. *added* to their load of 35 cwt. each, and the end springs would have as much *deducted* from them. This makes the variation of the duty of each spring only 10 per cent. above or below the original load. The strains produced by expansion or contraction of the boiler shell would be proportionately insignificant.

The number and arrangement of the bearers and suspension rods, and the way in which the latter are secured to the boiler, are all matters of importance, whether springs are used or not.

The object to be aimed at is the perfect distribution of the weight under all circumstances. Looking at a cross section of a boiler taken near one of the bridges (see Fig. 2), it is obvious that the suspension rods exert an upward force upon the upper part of the shell. It is equally obvious that the water and weight of the lower half of the shell exert a downward force upon that half, acting in a perpendicular line drawn through the centre of the boiler. These two opposing forces tend to draw the circular shell into an elliptical form, the ellipticity varying with the intensity of the forces. To avoid this destructive action it is advisable to add a T-iron strut across the boiler and within it immediately under each bearer. This strut, acting in concert with the arched T-iron outside, forms a rigid girder convenient for the attachment of the suspension rods, and rendering impossible any departure from the circular form.

Next, as to the distribution of the bearers. There should be one for every 15ft. if the boiler be 4ft., and one for every 12 feet if 4ft. 6in. diameter. The boiler should be divided equally into as many imaginary sections as bridges are required, and the bridges should be placed each in the middle of a section. So that after being hung, if the boiler were really cut into these sections, each one should remain undisturbed and independent of support from its neighbours.

The bearers of boilers Figs. 3 and 4 are not so distributed, and are, in so far, defective. If the distribution recommended be adhered to, and three suspension rods be used to each bearer, then the weight falling to the share of each rod would be proper for an ordinary volute spring, viz., about 1¾ tons.

As there is a possibility that some may still have an impression that the evil, for which a remedy has been tendered, does not exist, or has been exaggerated, or has not been traced to its proper cause, or would remain notwithstanding all precautions, it has been thought desirable to offer the opinions of several well-known authorities who have been consulted by the writer whilst this paper was in course of preparation. Thus, Mr. R. B. Longridge of the Boiler Insurance and Steam Power Company writes:—"I have known several cases of fracture such as those to which you refer. They have in most cases become apparent while steam was being raised for the first time after the boiler had been laid off for cleaning. In my own opinion the evil results from unequal expansion, owing to the practice of blowing off the water before the brickwork had time to cool. I believe the length of the boiler, and to some extent the setting, exert an influence. In some instances much expense had been incurred, but after an explanation of the cause of the difficulty was given, and more time was allowed for cooling before releasing the water, no further trouble was experienced. An exception must, however, be made with respect to certain cases where the fractures were attributable to overheating, owing to the presence of carbonate of lime in large quantities. I have known several explosions due to the extension of such ruptures round the entire circumference. Boilers have thus been divided into two parts without being affected anywhere else."

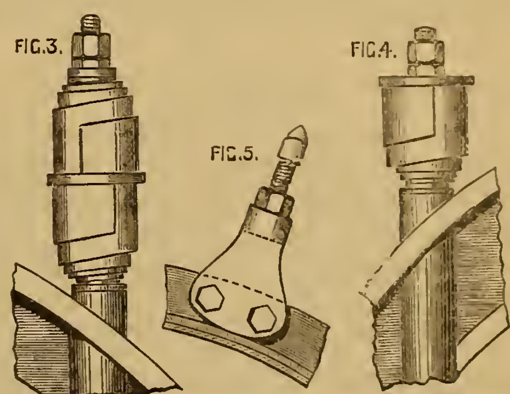


FIG.3. FIG.5. FIG.4.

Mr. L. E. Fletcher, of the Manchester Steam Users' Association, writes thus:—"We understand the inquiry—'Have you found plain cylindrical boilers to break their backs?'—to refer to failure at the ring seams—and our reply is, 'Yes, often.' As to the period of the week at which this happens, it is frequently immediately on starting after repairs. The greater the length of the boiler the greater the risk. We also think the plan of setting boilers with a flash flue tends to increase the danger. Explosions are very frequent from the failure of externally-fired boilers at the ring seams, and the expense and trouble is, of course, very considerable.

In Mr. Fletcher's report for November, 1867, the following passages occur:—"Externally-fired boilers are very prone to these treacherous fractures at the ring seams of rivets, and they may happen at any moment without warning. Hence one of the great objections to these boilers; sometimes merely opening the furnace doors, and admitting a rush of cold air is sufficient to rend them at the ring seam of rivets, near the fire-bridge. I cannot conclude the report without urgently repeating the appeal to colliery owners, so frequently made on previous occasions, that they would give up the use of these treacherous and uncontrollable plain cylindrical, externally-fired boilers, and adopt the internally-fired double furnace boiler instead."

Mr. E. B. Marten, of the Midland Steam Boiler Inspection and Assurance Company, writing from Stourbridge, says—"The plain cylindrical boilers about here are too short ever to break their backs; at least, I know of no case like those I remember in Cleveland. We did suppose it was only in frosty weather, but lately we have had cases traceable to sudden changes of temperature by irregular working. We think them due to the difference of expansion between the hot bottom and the cold top; and that the mischief is developed at the sides, midway between; seam rips appear there which soon become dangerous. I think extreme length is the cause, and that the remedy is to divide the boiler into two or three, joined perhaps by narrow necks."

Mr. Waller, engineer for the northern district of the Midland Company, gives his opinion thus:—"I am at present occupied in preparing a report upon the seam rips of plain cylindrical long boilers, and their habit of lifting at the ends. The habit is not, however, peculiar to them, but is also found with one and two tubed internally-fired boilers. Seam rips proper, and seam rips from fire, should be kept distinct. I do not now remember any explosion from the former, but several from the latter cause, and also from rips caused by repairs and drifting. I should like you to try the springs with a pointer, at a place where a boiler 70ft. long has occasioned much trouble by lifting $\frac{7}{8}$in. at the front end and $\frac{1}{2}$in. at the back. Some only 40ft. long are also lifting."

Mr. Gjers, of Middlesbrough, who always adopts these boilers, thus answered the queries put to him :—"I have, fortunately, not been myself much troubled by reason of boilers breaking their backs. I have under my care plain cylindrical ones from 75ft. to 80ft. long, but I never had a very bad case. I never knew a boiler explode from that cause; but some ten years since one in the Cleveland district was lifted out of its seat. It did not, however, fall into two pieces. The reason is clearly continuous expansion and contraction, which in course of time produces straining of the seams, and ultimately failure. The larger the boiler the more it will be affected. Workmen are sometimes so stupid as to screw up the nuts of the end supports when they find them slack, and the result is to throw the whole weight upon the ends so soon as the boiler cools. With a boiler 60ft. long we are not, as a rule, much troubled by slackening of the nuts of the end supports, but if this does take place we never touch them. Blowing off the water while the flues are still hot is also a fruitful source of danger to boilers, and especially if, when the bottom is thus extra heated and expanded, an ignorant attendant tightens up the end nuts as just explained. I think these evils are to a great extent avoidable with due care, and that plain cylindrical boilers are not intrinsically objectionable. The difficulties increase if the water is impure, but even then they are not insuperable."

ON THE CONDITION OF CARBON AND SILICON IN IRON AND STEEL.

By Geo. J. Snelus, Associate, Royal School of Mines.

No one can examine the statements contained in the metallurgical works regarding the condition of carbon and silicon in iron and steel, without being struck with their vagueness, and with the unsatisfactory state of our knowledge of this important subject. That these elements do exist, in some form or other, and that they exercise an all-powerful influence upon the nature of the metallic compound, is admitted by all, while in the case of carbon, at least, it is now generally allowed that it may exist, either diffused through the mass, as graphite, or be present in some form of combination with the iron. But there are no proofs that this diffused graphite, or "kish," as the workmen term it, when it occurs on the surface, is pure carbon, nor any very satisfactory data as to the nature of the combination of iron and carbon; and it is only necessary to state a few of the theories on the latter point, to show that we require more workers in this field of research, to clear up the mist in which the subject is at present shrouded. As a small contribution in this direction, the following results are submitted to the members of the Iron and Steel Institute.

Thus while Bertheir believed he had discovered a simple compound of one atom of iron with one of carbon, that is in the proportion by weight of 28 parts of the former with 6 of the latter; Berzelius believed in the existence of a compound of two atoms of carbon with one of iron, and also of one with three atoms of carbon to two of iron; Karsten and Rainelsberg hold to a compound of four atoms of the metal with one of the non-metals. Gurls advocates the existence of a further compound of eight iron to one carbon, and lastly, Von Mayrhofer thinks that definite substances of the formulæ Fe 4 C, Fe 5 C, Fe 8 C, Fe 10 C, and Fe 12 C, may be present under different conditions.

With respect to graphitic carbon our ablest metallurgist, Dr. Percy, in his justly celebrated work on iron and steel has the following statement, which, so far as the author knows, has not hitherto been contradicted. Speaking of the separation of graphite from pig iron, he says, "The fact of graphitic carbon being left by the solvent action of acids is certain evidence that this carbon was not present in the solidified metal, at least in a certain degree, in chemical combination with the iron. With regard to any distinct flakes of graphite which may be separated, there can be no reasonable doubt, though according to my experience, even they retain iron in some form or other, which it is difficult to dissolve out completely. Moreover, when we carefully inspect the fractured surface of a piece of even highly graphitic iron, every part presents more or less of a graphitic lustre, *yet not a trace of graphite can be detached by the point of a penknife.*

It was this latter statement which led to the following investigation, the details of which, the author thought, could not be placed before a more fitting audience than the members of the Iron and Steel Institute. The methods of analysis followed in order to elucidate the condition of carbon and silicon have opened a fresh field of research, which will be alluded to in its place, and which it is hoped may lead to further and more important results.

But if the practical bearing of the investigation be not at present apparent, the author hopes his contribution may not be unacceptable to the members of the Iron and Steel Institute, as he believes the day has gone by for practice alone to reign supreme, and that rapid progress in manufacturing industry is only to be obtained when theory and practice go hand in hand.

There is no subject requiring more study than the chemistry of iron and steel, for every step in their manufacture involves a chemical problem, and the author cannot let the present opportunity pass, without suggesting the desirability of this institution affording substantial aid in the matter, by the establishment of a laboratory for research. The British Association are doing something, but what is now suggested is the appointment of a chemist who should be in communication with the great body of scientific ironmasters throughout the country, and be able to verify results, not by mere laboratory experiments, but by actual trials on a manufacturing scale.

The incorrectness of the statements respecting the separation of graphite from crystals of iron, became evident from the examination of some largely crystallised pig iron, which having run over the symp, had cooled slowly in a tub of slag. It was noticed that, in this case, the graphite could be separated from the faces of the crystals, not merely by the point of a penknife, but even by the finger nail; and that having once detached the scale of graphite, the surface beneath was metallic iron. On exposure to a damp atmosphere, it was found that the metal became rusted below the scales of the graphite, which then fell off. Continuing the observation, it was found that tho same separation of graphite could be obtained from the faces of the crystals of Bessemer pig, and that the smallest crystal of grey iron was coated with its layer of graphite, which by appropriate means conld be easily removed.

This being the case, it was at once seen, that by carefully removing these graphite scales, we ought to be able to settle the question whether they where pure carbon, or a compound of carbon with iron, silicon, &c. It need scarcely be stated that the separation of a sufficient quantity of these scales for an analysis, is a tedious operation, and that even with the greatest care it is almost impossible to prevent fine particles of iron, dust, &c., from contaminating them. By a little trouble, however, ·0345 grammes of these scales were removed from the facets of crystals of *compact* grey iron. These were burnt in a stream of oxygen, when there was left a residue weighing only ·0015 grammes, consisting mainly of a few miscroscopic particles of sand with the merest trace of red oxide of iron, resulting no doubt from the oxidation of the foreign particles of metal with which the graphite was contaminated. The carbonic acid found weighed ·104 gramme, which is equivalent to ·2083 grammes pure carbon, so that, even if the incombustible residue had been all peroxide of iron, there must at least have been 126 atoms carbon to one of iron.

As the graphite could be thus easily removed from crystals of pig iron, it was thought that other mechanical processes might be applied for its separation, and that the magnetic property of iron might also be made available. Some graphitic pig was therefore pounded, in a steel mortar, to coarse particles which, by their attrition, rubbed off the scales of graphite from the crystalline facets. The iron was removed by a magnet, and the graphite left behind. But here it was still more difficult to remove the last traces of metal. ·1045 grammes of the graphite, after combustion, left a residue weighing ·012 grammes consisting of ·008 oxide of iron and ·004 sand, silica, &c. As the Fe 2 O 3 would be formed from ·0056 grammes iron, and ·0024 grammes oxygen absorbed, this latter weight must be added to the loss by combustion, thus making the total graphite burnt ·0949 grammes. The carbonic acid found weighed ·3505 grammes—·0955 grammes pure carbon, so that even here there was 17 times as much carbon as iron, or 46 atoms metal to one of the non-metal.

Lastly, ·1415 grammes of kish purified with hydrochloric and hydrofluoric acids gave ·518 grammes carbonic acid, equal to ·14,154 grammes pure carbon, and left no residue that could be weighed.

These results, we think, are sufficient to prove that scales of graphite can be removed from compact grey iron, and that these scales consist of pure carbon, for it is morally certain that the traces of iron found with them were simply accidental, and in no way combined with the carbon.

Graphite being much more friable than metallic iron, it was believed that it would be reduced to finer powder than the metal in the process of drilling. Some grey Bessemer pig was therefore reduced to borings, and these were sifted through a very fine silk sieve. The original pig, coarse part, and fine portion which passed through the sieve were analysed separately, with the following results :—

Total Carbon per cent. in three trials on different pigs.

Original pig.	Coarse part of borings.	Fine part which passed through the sieve.
(1.)—3·008	2·552	7.605
(2.)—3.331	—	9.214
(3.)—4.071	—	9.288

Again, graphite being so much lighter than iron, recourse was had to specific gravity as a means of separation. Two makes of iron were employed, viz.: A Middlesbrongh grey forge pig, and ordinary Bessemer pig. The borings from each were divided into two portions, one-half being sifted as above, and the other part separated by agitating with distilled water and pouring off the lighter portions for analysis. These several products were completely analysed with the results recorded at pages 230 and 231. The carbon per cent. found in each case was:

		Original Pig.	Fine part separated by sieve.	Light part separated by specific gravity. per cent.
(1.) Bessemer Pig	graphite	3.331	9.11	28.48
	combined carbon	—		—
(2.) Bessemer Pig	graphite	3.190	7.79	21.274
	combined carbon	.2	.17	—
(3.) Middlesbro' Forge Pig	graphite	2.650	7.015	41.329
	combined carbon	.35	.30	—

The results show clearly that in grey pig iron the carbou exists in two states, and that the free or graphitic carbon, can be more or less separated by mechanical means, while the so-called "combined carbon" decreases in the separated portions in the same ratio as the residual iron.

In spiegeleisen, refined metal, white pig, steel, and wrought iron, almost the whole of the carbon exists in combination, very little graphite being present; bnt the amount of graphite, as is well known, depends to some extent npon the rate of cooling of the fluid iron. Thus, if even grey Bessemer pig be cast in chill moulds, the outer portions will be white and "case hardened," and as a proof that there is less graphite in this than the central grey part the following analyses of a piece of bad forge pig may be cited. It will be seen that the white portion contains .25 per cent. less graphite than the grey, although the total carbon was the same in each case.

		Composition of white part.			Composition of grey part.
Iron		92.240			92.150
Carbon	Graphite	.850	2.573	Grte. 1.100	2,584
,,	combined	1.723		cbd. 1.484	
Silicon	1st estimate.	3.978	3.972	4.001	3.984
,,	2nd ,,	3.966		3.971	
Sulphur		.355			.375
Pbosphorus		.702			.731
Manganese		.216			.234
Other metals		absent.			absent.
		100.058			100.063

Tbe largest amonnts of graphitic carbon are contained in grey Bessemer pig; and of combined carbon in spiegeleisen, this alloy of iron aud manganese having tbe property of retaining carbon in "combination" to a greater extent than iron alone. Some old analyses have been published, in which tbe total carbon in different classes of iron is shown as high as 6 per cent.; but in some hundreds of analyses of all brands of iron that have been made by tbe author, he has never, in a single case, fonnd the carbon to reach 5 per cent., and this, he tbinks, will be corroborated by all who have made analyses with our modern improved means of research.

From tbe experiments of our V.P., Mr. I. D. Bell, it wonld appear that some of this carbon is taken up by the ore during tho process of reduction; bnt it is commonly supposed tbat the greater portion is taken np after complete reduction, and that tbe great cause leading to high carbon in pig iron is long contact of the fused metal at a high temperature in contact with carbon. The nature of the slag has an important effect in determining tho quantity of carbon, whicb appears to reach its maximum when the blast is hottest, slag most basic, ores least silicious, and burden light.

Whether there is any definite chemical componnd of carbon and iron, or as Dr. Percy suggests, of carbon, iron, and manganese, tbere are, we think, no data to decide; but judging from the few experiments wbich have been made, wo are inclined to believe that the absorption of carbon by iron is a case of that weak kind of chemical action termed solution, and that there is no definite chemical compound of tho two elements. It appears more probable that iron dissolves carbon *per se*, and retains it more or less on solidifying, according to tbe quantity that has been taken up, the proportion of manganese present, the rapidity with which cooling is effected, and tbe amounts of such other bodies as silicon, sulphur, phosphorus, &c., held by tho iron. It is generally tho case that solution of a solid takes place more freely the higher the temperatnre, and so it appears to be with iron and carbon. Tbat the carbon retained in the iron from mere solution should so marvellously affect its nature, according to the quantity present, is no greater wonder tban tbat the diffnsion of a small quantity of a definite chemical componnd, of any ore of the formulæ proposed should do; and altogether it seems more simple, and in accordance with fact, to suppose that carbon is held in solution and not in chemical combination in the ordinary sense of the term. The properties of any other solvent are more or less altered by dissolving various substances in it. Water, for instance, dissolves varying quantities of common salt according to the temperature, and although it will take np a certain weight without altering its bulk, yet the specific gravity is increased, freezing point lowered, and in many respects it is different from pure water. Again, after it has been saturated with salt, it is still capable of dissolving other bodies, as, for instance, alum. No one, however, regards the union as water, salt, and alum, in this case as a definite chemical compound. Why then should not the nnion of carbon with iron be regarded as a similar case of solution? The fact that the union remains on solidification has its parallel iu the case of mercury, which dissolves tin, in varying proportions, and the union remains on solidification.

Silicon.—This element is invariably contained in pig iron; and the author has never yet met with a case of even steel or wrought iron, in which it was entirely absent, though iu good Bessemer and tool steel it rarely exceeds two or three parts in 10,000 of iron. When present in Bessemer steel, to the extent of about one-tenth per cent., or one part in 1,000, it has the effect of rendering steel hard and brittle when cold. Its presence in iron is due to the reduction of silica, which takes place in the blast furnace; and the conditions favouring its passage into irou are high temperature, light burden, free silica in the charge, and deficiency of lime, alumina, and other bases in the slag. It is also sometimes stated that the quantity of silicon passing into the iron will depend upou the pressure in the blast, but this evidently resolves itself into a question of temperature, as the greater tbe pressure, within certain limits, the more intense will be the combustion.

In ordinary Bessemer pig, silicon occurs in quantities varying from 1 to 4 per cent., while white pig iron may contain mere traces, and spiegeleisen has seldom more than a few tenths per cent. It gives considerable trouble to the puddler in removal, and occasions great loss of yield in the process. Hence the desirability of having forge pig as free as possible from silicon. In the Bessemer process, on the other hand, it serves a very useful purpose, as during the blow it is burnt or oxidised, with the evolution of much heat. But, as in puddling, it occasions considerable loss of iron, aud provided a sufficient temperature can be obtained, the less silicon there is in the pig tbe better. As, however, carbon is never present in sufficieut quantity to generate all the heat required iu the process, it is only when the iron contains largo amounts of manganese that silicon can be dispensed with below about 2 per cent. In some Swedish and Styrian Bessemer pigs, containing about 3 per cent. manganese, the silicon is under 1 ounce, and yet the charge works very hot.

When iron or steel is dissolved in mineral acids, the silicon is oxidised, and silica separates along with the graphite in a gelatinous state; hence it is generally believed to have been iu chemical combination witb tho iron. It is, however, an element similar in many respects to carbon. This carbon is known to exist iu at least three different states, viz.: crystalised as the diamond, in semi-crystaline condition as graphite, and in an amorphous state as charcoal, lampblack, &c. Silicon has also been obtained in a pulverulent or amorphous form, in a graphitic state, and in the adamantine (or diamond) crystallised condition. One would then naturally expect that it would be found in irou in tbe same state as carbon, and, indeed, this is tho generally received opinion; but a careful examination of the proofs of its existence in the graphoidal or free state failed to satisfy the author that this was the case.

As silicon, like graphite, is non-magnetic, and of low specific gravity (2.49), it appeared to the author that if it existed in tho free state, the method which succeeded in separating graphite should also answer for the separation of silicon.

Tbe following analyses, some of which are of very silicious pig, show that silicon cannot be separated in this way:

Amount of silicon per cent. in

	Original pig. 1	Coarse part. 2	Fine part separated by sieving. 3	Light portions separated by sp. gr. 4
West Cumberland Bessemer Pig	2.419	2.447	2.380	—
Dowlais B. Pig	3.77	—	3.433	2.93
,, ,,	3.489	—	3.639	3.158
Middlesbro' Pig	1.815	—	1.610	1.219

Thus we see that instead of the silicon increasing in the finer aud lighter portions, as the graphite did, the reverse is the case. It actually decreases, and in the same proportion as the carbon increases; in fact it remains with the metallic iron just as the "combined" carbon does, so that the coarse part, after removing some graphite, contains an increased proportion of iron and silicon, while the finer portion contains a less per cent. of these elements. It appears, then, that it must have been in combination or solution in the iron, and that it is, at least, an exceptional case, if it is found in the free state.

It may be well here to allude to those cases in which silicon has been stated to have occurred free. The most important instance is that of Richter of Leobon, who asserted that he had found silicon in defined crystal in pig iron; but the editors of "Kerl's Metallurgy" suggested that this "may have been a compound of silicon and iron, as a small amount of iron was found in it." Percy states that the late M. Henry believed he had crystallised silicon among the scales of graphite from pig iron, and that he himself regarded the evolution of gas like hydrogen, which took place on putting some graphitic scales (obtained from one of the Dowlais furnaces as "kish") into molten potash, as most probably caused by the pressure of free silicon.

The balance of evidence then appears to favour the theory that silicon is dissolved, or (to borrow a word which perhaps more nearly expresses the state of combination) "occluded" in the iron in the same way as carbon, but that the solvent power of the metal is so much greater for silicon than for carbon that it is quite a rare thing, even if it ever occurs, for silicon to separate in a free state from the iron.

This greater solvent power for silicon is fully proved by the fact that carbon never exists to a much greater extent than five per cent., whereas Scotch pig iron has been found with as much as eight per cent. silicon, and Dr. Percy succeeded in obtaining a melted metallic product with 18.77 per cent. silicon by reducing sulphide of iron into contact with sand and charcoal; indeed it seems to be an easy matter to obtain a compound of iron with 10, 12, or 15 per cent. silicon. The author has not yet had an opportunity of applying the methods of mechanical separation to such products as these, but hopes to do so before long. It is generally supposed that the absorption of much silicon tends to set free carbon in the graphitic state. Pig iron containing much silicon melts readily, and is generally weak and easily broken; and, indeed, from long observation, the author can generally tell whether Bessemer pig contains high or low silicon, by the facility with which the workmen break the pigs by dropping them on to the ∧ iron.

No direct experiments have been made on the tensile strength of pig iron containing a constancy of other elements with varying quantities of silicon, but Fairbairn and others have ascertained the strength of particular brands of pig iron after several successive meltings, and found that the metal generally increases in strength up to a certain point, and then each fusion reduces the resistance to rupture. Now, the author believes the explanation of this to be that at each successive melting the silicon, and perhaps, to a slight extent the carbon, decreases; but the iron gradually takes up sulphur and phosphorus from the fuel, and the deterioration due to these elements more than counterbalances the increased strength due to diminished silicon and carbon. This theory seems to be borne out by the specific gravity of the samples which show a gradual increase throughout.

According to Price and Nicholson, Culvert, and Johnstone and Lan, nearly the whole of the silicon is removed in the process of puddling before the carbon is touched, but it by no means follows that, because it is easily oxidised, it has no injurious effect in delaying the process; indeed, the author has very positive evidence that the reverse is the case.

In the Welsh refinery process, and also in the Heaton process of conversion, the same rapid removal of silicon takes place, as is seen in the following analyses:

		White Pig Iron.		Refined Metal made from former.
Iron ...		94.006 ...		96.485
Carbon ...	Graphite .8 } Combined 1.797 }	2.567 ...		2.428
Silicon ...	1.918 } 1.899 }	1.908 ...	.126 } .130 }	.128
Sulphur ...		.553 ...		.144
Phosphorus		.886 ...		.815
Manganese		.050 ...		trace
		100.000		100.000

Conversion by Nitrate of Soda Process.

	Mixed Pig Used.		Samples of Crude Converted Metal made from preceding.	
	A.	B.	Hard Piece.	Soft Piece.
	direct 93·967	by diff. 94·030	direct 97·435	by diff. 98·486
Iron	2·36 graphite } ·446 combd. } 2·806	0·570	all combd. 2·061	1·093
Carbon ...... Silicon	2·011 } 2·002 } 2·006	1·946 } 1·973 } 1·959	·014	trace
Sulphur......	·034	trace	trace	trace
Phosphorus	·426	·558	·489	·344
Manganese	·648	·885	·064	·072
	99·937	100·000	100·000	100·000

It was formerly supposed that in the Bessemer process the whole of the silicon was removed before the carbon was touched; but, as was stated by Mr. C. P. Sandberg (in a paper communicated by him to the Institution of Civil Engineers) from experiments by the author of this paper, it has been found that this is not the case. These two elements are both rapidly oxidised from the commencement of the blow, but the silicon being more easily attacked disappears quickest. If, however, the pig iron contains an excess of silicon and but little carbon, this latter may be all burnt out, and the body of flame disappear, so that the workmen may suppose the metal to be fully blown, while it still contains sufficient silicon to render the steel very brittle. This is, of course, a *very* exceptional circumstance, and can never take place if the "charge" is probably regulated, but that it does sometimes occur is fully proved from the following analyses of underblown steel, which, it is right to state, are the only instances of the kind that have come under the author's observation during the course of his extended experience at the Dowlais Works. He had been informed, however, from other metallurgists, that they have occasionally met with similar instances.

The gradual oxidation of the carbon *along with* the silicon from the commencement is shown by the following analyses of metal, taken during the blow. These statements regarding the removal of carbon and retention of silicon, have since been corroborated by Professor Tunner, and also by a Swedish metallurgist of repute.

Analysis of the Bessemer Metal during the "blow" of the Pig used and Steel produced.

	Melted charge of Pig.			No. 1 Sample, taken at the end of first stage, six minutes from start.		No. 2, taken nine minutes from start.		No. 3, taken at finish, before adding spiegel. 13 minutes from start.		Steel borings from an ingot.		Steel borings from rail crop ends.	
Iron			94·682	——	92·245	——		——		——		——	
Carbon	Graphite Combined	2·06 } 1·20 }	(a) 3·218	——	(b) 2·127	—	1·55	—	·097	—	·566	—	·519
Silicon	—— ——	1·964 } 1·941 }	1·952	·792 } ·798 }	·795	·635 } ·635 }	·635	—	·020	—	·630	—	·033
Sulphur............			·014	——	trace.	—	trace.	—	trace	—	trace	—	trace
Phosphorus	—— ——	·050 } ·047 }	·048	·055 } ·048 }	·051	—	·064	—	·067	—	·055	—	·053
Manganese			·086	——	trace.	—	trace.	—	trace	—	·309	—	·309
Copper			——		——		——		——	—	·039	—	·039

(a) The total carbon is estimated by direct combustion, the graphite and combined by separate experiments. (b) All combined.

Middlesbrough Grey Forge Pig.

	A.—Original pig iron.		B.—Fine part, which passed through silk sieve, about No. 130.		C.—Light portions separated by specific gravity, by washing.	D.—Lightest portions separated by specific gravity by washing.
Iron					57·735	54·733
Carbon	Graphite { 2·66 direct, 2·61 by H F }; Combined ·35	3·000	Graphite { 7·05, 6·98 }; Combined ·3	7·315	Graphite 37·623	Graphite 41·044
Silicon	1·81, 1·82	1·815	1·60, 1·62	1·610	1·240	1·211
Sulphur	·068 by Ag. Regla; ·073 by H Cl & K Cl Oz	·070	·205, ·173	·189	·760	·644
Phosphorus	1·79, 1·77	1·780	1·81, 1·74	1·770	1·345	1·344
Manganese	·504, ·490	·497		·482	1·383	·875
Calcium	Absent.		Absent.		Absent	Absent

Dowlais Bessemer Pig Similarly Treated.

	A.		B.		C.	D.	
Iron					86·101		74 278
Carbon	Graphite { 3·04, 2·94 }; Combined ·2	3·19	Graphite { 7·64, 7·60 }; Combined ·17	7·790	10·111	Graphite	21·274
Silicon	3·826, 3·873	3·849	3·658, 3·621	3·639	3·443	3·131, 3·185	3·158
Sulphur		·011	·035, ·038	·036	·054	·068, ·065	·066
Phosphorus	·081, ·076	·078	·072, ·069	·070	·070	·058, ·058	·058
Manganese		·244		·230	·219		·164

Lest it should be supposed that the brittleness of the steel here mentioned, is in any way due to the presence of other elements, the analyses of ordinary Dowlais steel rails is given, which, it is well known, is seldom broken by the fall of the ton-monkey from a height of 20 to 30ft. An analyses of "iron skull," from a Bessemer reverberatory melting furnace exhibits the same phenomenon.

Underblown steel containing high silicon.	
No. 1 Carbon	.445
Silicon	.814
No. 2 Carbon	.515
Silicon	.279

Iron-skull from melting furnace.	
Iron	98.384
Carbon	.729
Silicon	.965
Sulphur	.110
Phosphorus	trace
Manganese	trace
	99.852

	Brittle with high silicon.		Good steel.
Iron		98.120	98.831
Carbon		.530	.490
Silicon	.634, .644, .644	.640	.009
Sulphur	.069, .066	.067	.033
Phosphorus		.038	.036
Manganese		.554	.576
Copper		.031	.025
		100.000	100.000

Wrought iron is frequently to be met with, which is not at all brittle and yet contains enough silicon to have produced decided cold shortness in steel. The author believes that this apparent inertness of silicon is in part at least due to the fact that in any product like steel which has been molten, the whole of the silicon present must be in the combined or "occluded" condition, while in the case of wrought iron which has been in a pasty state, much of the silicon shown in analyses really occurs as silica in the interposed slag, which does not materially affect the strength of the metal, but renders its wearing properties vastly inferior to those of steel. The author has recently met with a sample of iron, containing a large per cent. of this interposed slag, and found the composition in this case to be:

Silicon ...	.155	in 1.069 slag,
Phosphorus	.189	
Iron ...	.231	

which, if calculated to the states in which these bodies probably existed, would be:

Silicon	.333	equal to 31.25 per cent.
Phosphoric acid	.433	" 40.405 "
Peroxide of iron	.297	" 27.843 "

It is this interposed slag which renders built up or "piled" rails so liable to be crushed, as it prevents perfect union or welding of the crystals of iron.

In like manner very fair wrought iron often contains amounts of sulphur and phosphorus that would be fatal to steel, and the same explanation may probably be applied here.

There does appear, however, to be some difference in the modes of existence of sulphur and phosphorus in pig iron, or in completing the analysis of the various products obtained by mechanical separation as explained above, the author was struck with the remarkable and unexpected fact that the finer portions which contained most graphite contained also an increased per cent. of sulphur, while the phosphorus decreased in about the same ratio as the iron. The manganese also appears to accompany the sulphur to some extent.

It might possibly be thought that this difference arose from errors of analysis, but it is too great to be thus accounted for even with the most careless manipulation, while the author need scarcely state that every possible precaution to guard against error has been taken, and not only have almost all the experiments been made in duplicate, often in triplicate, and when possible by two different methods, but the re-agents were carefully tested for purity and the precipitates proved to be pure, and what they professed to be.

This part of the subject requires further investigation, and the author hopes at some future time to communicate the results of additional experiments. There is no doubt that the methods of mechanical separation adopted by the author for the investigation of the condition of carbon and silicon will prove effectual aids to the ultimate analysis of iron, and a valuable supplement to the ordinary methods of research.

The following is a complete analysis of samples of pig iron after mechanical separation of their constituents:

Coarse part of borings remaining after the separation of C and D—Middlesbrough Pig.

Iron	94.00
Graphite	1.884
Silicon	1.885
Sulphur	.060
Phosphorus	1.773
Manganese	.490

Dowlais Bessemer Pig.

Iron	93.708
Graphite	2.072
Silicon	3.880
Sulphur	.011
Phosphorus	.79
Manganese	.040

It should be mentioned that of 712.8 grammes of fine borings of the Middlesbrough pig 68.8 grammes or 9·65 per cent. passed through the sieve, and formed the part marked B in analysis, while of 2,551 grammes of Dowlais pig 191 were passed through the sieve. In the case of the light portions separated from the remaining halves of the borings by specific gravity, only a very small proportion of the whole was obtained which was not estimated.

In concluding this paper the author begs to record his appreciation of the efficient services rendered in the above investigation by his assistant Mr. W. Jenkins.

ON PYROMETERS.

By C. William Siemens, F.R.S., D.C.L.

The mercury thermometer which enables us to estimate ordinary temperatures with such admirable precision, fails to indicate heats exceeding the boiling point of mercury (500° Fahr.) and although many attempts have been made to produce a reliable high temperature thermometer (or pyrometer) it can hardly be said that such an instrument is now in the hands of the practical metallurgist.

Amongst the attempts which have been made in this direction the Wedgwood pyrometer occupies the first position. It is based upon the peculiar property of fire-clay to shrink permanently when exposed to intense heat and upon the supposition that the amount of shrinkage in question was proportionate to the intensity of the heat to which the ball of fire-clay had been exposed. The error involved in this supposition becomes at once apparent if we consider that the shrinkage of the ball is caused by the expulsion of water of hydration which must necessarily take place chiefly at one particular temperature. It is proved, moreover, by the very discordant and, in fact, impossible results, recorded in chemical works as being obtained by means of this instrument. Thus we find it stated in Dr. Lardner's popular treatise, that cast iron melts at a temperature of 17,977° Fahr., and that iron welds at a temperatute of 21,000° Fahr., whereas it can be proved that the utmost temperature to be obtained by the combustion of carbon with a blast of atmospheric air cannot exceed 4600° Fahr., which degree of temperature far exceeds the points of heat to be met with in metallurgical processes, not excepting even the melting point of mild steel, which comes nearest to the maximum point here indicated.

Amongst the other pyrometers that have been proposed from time to time is the air pyrometer, which is limited by the melting or softening point of the vessel confining the air; the pyrometer by difference of expansion of two metals which has lately been brought forward in a compendious form by Mr. Gauntlet, but which cannot be relied upon beyond a point approaching red heat, at which permanent elongation of the metal sets in; and a pyrometer by contact of two dissimilar metals setting up an electric current capable of measurement, which, however, is by no means proportionately progressive with increase of temperature.

Another pyrometer has been based upon the well-founded supposition that the specific heat of metallic bodies is the same at various temperatures, and that by measuring the heat of a ball of metal after it has been exposed to the heat to be estimated, a true measure of its intensity is obtained. I have myself constructed an instrument upon this well-known principle, which has found considerable favour with ironmasters in measuring the temperature of hot blast, and for other purposes. It consists of a portable vessel composed of three concentric cylindrical vessels of thin copper-plate, the two interstine spaces being filled; the inner one with cow-hair, and the outer one with atmospheric air, and the two together forming an excellent barrier against loss of heat from the interior of the vessel.

A delicate mercury thermometer is fixed in the interior of the vessel, being protected by a perforated shield, and furnished with a movable sliding scale showing pyrometer degrees, of which one is equal to 50 ordinary degrees. The instrument is accompanied by balls of copper or platinum, which are so adjusted that fifty of them would be equal in thermal capacity to an imperial pint of water. Each ball is perforated by a hole through which a rod is passed in exposing the same to the action of the heat to be measured. Immediately before using the instrument, an imperial pint of water is poured into it, and the pyrometer slide is so moved that its zero point coincides with the top of the mercury column in the thermometer tube. The ball is thereupon exposed to the heat for two or three minutes, and plunged into the water. The mercury will be observed to rise, and the absolute temperature of the place measured is ascertained by adding the reading on the pyrometer scale, opposite the new level of the mercury, to the degrees of temperature indicated by the thermometer before the ball was introduced. In using ordinary dexterity very satisfactory readings may be obtained with this instrument, but its application is limited to the point of heat at which the metal ball employed begins to deteriorate, nor can it be employed for measuring the temperature of inaccessible places.

It has been my endeavour for several years to devise a pyrometer of a more universal applicability, and containing in itself more absolute proof of correctness, and, after a long series of experimental investigations I have succeeded in producing an instrument which I can confidently recommend to the practical metallurgist. It is based upon the peculiar properties of the pure metals to offer an increasing resistance to the passage of an electrical current with increase of temperature. A platinum wire of known electrical resistance is wound upon a cylinder of fire-clay, upon which a helical path has previously been cut to prevent contact between the turns of the wire. The coil of wires, so prepared, is enclosed within a cylindrical casing of platinum if the temperatures to be measured exceed the welding heat; or of iron or copper if lower temperature only requires to be measured. The two ends of the coil of wire are brought out endways and are attached within the protecting tube to thicker leading wires of copper, insulated for a short distance by being passed through pipe-clay tubes, and further on by india-rubber, or gutta-purcha, terminating at the measuring instrument, which may be placed at any convenient distance. This latter is of peculiar construction, its characteristic feature being that the usual calculations necessary in determining electrical resistances by the Wheatstone or other methods are dispensed with, and a reading in degrees of a large scale is at once obtained by so placing the index lever that the electrical current, generated in a small battery and passed through the measuring instrument, including the platinum wire of the pyrometer, produces a deflection of the galvanometer needle. These degrees do not express the temperature, but the temperature they represent is expressed by the accompanying table of reference, which has to accompany each instrument. The pyrometer coil itself, with its protecting casing, may either be fixed permanently at points, the temperature of which ought to be ascertained from time to time, or it may be introduced into a furnace through a door or aperture for only a minute or two, which time suffices to obtain a reading of the instrument. The latter is the only practicable method where the temperature to be measured approaches a welding heat which would in time destroy the protecting case of platinum or any other material; whereas, the former method of fixed coils will be the most convenient for measuring the lower temperature of drying or annealing stoves, or of the hot blast supplied to blast furnaces. At iron works with a number of hot blast stoves, a protected coil may be fixed within the hot blast tube leading from each stove towards the blast furnace, and the leading wires from each of these coils be brought into the office where the measuring apparatus would be placed. By such an arrangement the temperature of the blast of each stove of the furnace could be measured and noted at frequent intervals by a clerk without leaving the office, and very perfect record and control be thus obtained. The correctness of this instrument depends solely on the ratio of increase of electrical resistance in the platinum wire with increase of temperature. This rise is considerable, the resistance being increased fourfold by an increase of temperature from the freezing point to about 3000° Fahr. The ratio of increase is, however, not uniform, but follows a parabolic law which I have ascertained by a series of careful observations embodied in the table, and which form the subject of a separate communication to the Royal Socioty. I wish it to be understood that in developing these principles, I have been animated solely by a desire to fill up a blank in the means at our disposal to carry on metallurgical inquiries with such a degree of certainty as could not hitherto be realised without seeking for any commercial reward, through the Patent Office or otherwise.

FERRO-MANGANESE.

On the Production of Alloys of Iron and Manganese, and on their Application to the Manufacture of Steel.

By Ferdinand Kohn, C.E., London.

The properties of pure alloys of iron and manganese have not, as yet, been completely investigated. It is assumed by many metallurgists that the presence of a sensible proportion of manganese in malleable iron or steel, improves the ductility and elasticity of the metal, and that for this reason the addition of manganese is indispensable for the production of good cast steel. Other metallurgists, on the contrary, maintain that manganese has a tendency to produce hardness and great cohesive strength, at a sacrifice of those properties of malleability and ductility which are principally looked for in all modern kinds of "soft steel." According to this latter view, the function of manganese in steel making is simply to remove all surplus oxygen and silicon from the mass, and (in combining with these noxious elements) to disappear from the metal and pass into the slag.

This difference of opinions with regard to the theoretical position of manganese in the process of steel manufacture does not preclude an absolute unanimity amongst steel makers in this country and abroad, as to the practical necessity of employing manganese in the manufacture of cast steel. In the old process of melting blister steel in a crucible the addition of carburet of manganese—as patented by Josiah Marshall Heath in 1839—or the addition of an oxide of manganese mixed with a sufficient quantity of carbon for the final reduction of the manganese, are practised at the present day. The only modification which has been effected in recent years with regard to this process is the substitution of spiegeleisen, a substance which may be considered as an alloy of carburet of iron and carburet of manganese, instead of the pure carburet of manganese, originally employed by Heath. In the Bessemer process the addition of an alloy of iron, carbon, and manganese is an essential element of practical success, and a similar employment of manganese alloys has been adopted in the Siemens-Martin process, and in several other modern methods of steel manufacture.

The reduction of pure manganese from its ores, or the production of a pure carburet of manganese, presents considerable practical difficulties. The great affinity of manganese for oxygen, and the readiness with which the oxides of manganese combine with silica to form a slag which is liquid at a comparatively very low temperature, render every process for reducing metallic manganese extremely difficult to conduct on a large scale, and very expensive in practice. The production of metallic manganese has, therefore, never been successfully carried out in commercial practice; and it appears that Heath himself abandoned his original idea of manufacturing carburet of manganese, and perferred to charge the steel-melting crucibles with oxide of manganese and carbon, on account of the saving of expenditure attained by this change.

The principal supply of metallic manganese for modern steel manufacture is obtained in the form of alloys of iron and manganese produced by a variety of processes, and differing in their nature and qualities to a considerable extent.

Alloys of iron and manganese are reduced from natural or artificial mixtures of the ores of both metals with all the greater facility the higher the proportion of iron, and the smaller the percentage of manganese is required for the product. The ordinary pig iron produced in the blast furnaces of Sweden, Austria, and many other localities, contains from 1 to 3 per cent. of manganese. This is due to a small percentage of carbonate of manganese in the sphathic iron ores of these localities, and it is a mere question of the quantity of silica present in the slag which determines the exact percentage of manganese which is reduced and brought down with the metal.

A speciality of such pig iron, which contains a proportion from 7 to 11 per cent. of manganese, is the well-known spiegeleisen from the district of Liegen, in Rhenish Prussia. This pig iron is made from a spathic iron ore, which is a crystallised compound of carbonate of iron and carbonate of manganese, and which occurs in a large vein in a mountain called the "steel mountain," at Musen. The production of spiegeleisen, however, requires a particular management of the furnace; it is necessary to protract, as much as possible, that part of the smelting process which is destined to the carburisation of the reduced metals, and for this reason the charges must be so managed that the ores are quickly reduced, but that a long time is afforded to the reduced spongy metal before actual fusion takes place. The iron must be carburised at a temperature which is not sufficiently high for the reduction of silicon from the slag, yet at the same time the temperature at which manganese is reduced from its ore is nearly as high as that which will allow the silicon to pass into the metal. The presence of a considerable percentage of silicon, however, would prevent the production of specular iron, since the presence of silicon in molten iron has the tendency to drive the carbon out of its state of combination, and change it into graphite. The iron, instead of being specular, would become grey or mottled according to the temperature of the furnace, and its properties would be different from those of the spiegeleisen proper. On the other hand, if the temperature of the furnace, is too low, or the time required for the carburisation is too short, common white iron will be produced containing only a small proportion of combined carbon, and very little manganese.

The principal art in making spiegeleisen consisted formerly in making the ore capable of quick reduction by calcination, using burnt lime and only a small quantity of clay slate as flux, in order to reach the stage of carburisation as quickly as possible, and applying cold blast and charcoal in order to keep down the temperature of the zone of fusion, and thereby protract the preceding stage to the utmost extent possible. With recent improvements and the necessity for economy, the ironmasters of Liegen have learnt to make spiegeleisen with hot blast and coke, with utilisation of waste gases, and a high temperature in the zone of fusion. This is done principally by keeping out the silicon with an overdose of burnt lime, which also assists in preventing the sulphur from the coke from acting injuriously upon the iron.

With all these precautions, however, it is not possible to produce speigeleisen at all times and continuously in the same furnace. Fluctuations in the temperature and pressure of blast, and similar apparently very slight causes, will suddenly change the produce from spiegeleisen into grey or mottled iron, if the heat is excessive, or the slag too rich in silica, or the coke too much contaminated with sulphur; or common white iron will be produced if the temperature gets too low, or the burden too heavy. With the best managed blast furnaces, intended specially for making spiegeleisen, only 70 to 80 per cent. of the total annual produce is iron of that class, the remainder being either grey or white, according to the side to which there is a greater liability of error in the particular furnace.

The proportion of manganese in the spiegeleisen from the Liegen districts rarely exceeds 10 per cent., and the average percentage of manganese in this material is about 7 per cent. The quantity of combined carbon in the spiegeleisen is almost constant, and amounts to 5 per cent. In adding a dose of spiegeleisen to a charge of decarburised iron, it is, therefore, unavoidable that a proportionate quantity of carbon must be added for any given quantity of manganese which it is desired to introduce into the charge; and this leads to a difficulty in making very soft kinds of steel, which has always been very seriously felt by all Bessemer steel makers, and has been overcome only to a certain extent by great experience in the management of the converter. The actual necessity for making very soft steel with Liegen spiegeleisen is to "overblow" the charge to such an extent that there is oxygen enough left in the metal to combine not only with all the manganese and silicon, but also with the greater part of the carbon introduced by the spiegeleisen. This practice has made it possible to apply ordinary spiegeleisen to the manufacture of the softest kind of Bessemer steel; but it is an acknowledged makeshift, which has numerous well-known disadvantages, and the demand for richer alloys of iron and manganese has, for a long time past, been felt and acknowledged by every steel maker in this country.

Mr. Henry Bessemer was the first to point out this demand publicly in his specification for the manufacture and application of a so-called triple compound of iron, manganese, and silicon, instead of the ordinary spiegeleisen, to the manufacture of Bessemer steel. The mode of manufacture of this triple compound, as indicated by Mr. Bessemer, has been practically carried out by Mr. Prieger, of Bonn, and alloys of iron and manganese reaching occasionally as high a proportion as 60 per cent. of manganese, have been produced by this process. The mode of operation is understood to be as follows: A graphite crucible is charged with a mixture of granulated cast iron, peroxide of manganese, and powdered bottle glass, and to this a large proportion of powdered charcoal is added. The reduction of the metal takes place at a very high temperature, and the alloy is richer in manganese in proportion to the heat. This process has been taken up by several steel makers, but has been finally abandoned on account of the excessive expenditure which this mode of manufacture involves.

Another process for the manufacture of ferro-manganese has been invented and patented by Mr. Wm. Henderson, of Glasgow. The claims of Mr. Henderson's patents are embodied in several specifications filed between the years 1860 and 1869. The manufacture of ferro-manganese seems to have been intended by the inventor to form only an accessory part of his method of metal extraction, which is described in his numerous patents. This process has been at work for a considerable time at the Phœnix Foundry, in Glasgow, by Messrs. Thomas Edington and Sons. It consists in reducing upon the open hearth of a Siemens furnace a mixture of carbonate of manganese and oxide of iron, in the presence of an excess of carbon, and by means of a neutral or reductive flame. The furnace bottom is carefully prepared from ground coke consolidated and baked up to form a solid and durable carbon crucible on a large scale. The charge of oxides is ground up to a fine powder, and intimately mixed with powdered charcoal or coke, and the whole mass when charged and heated to a red heat for several hours becomes converted into a metallic sponge containing the reduced metal from both oxides, which is capable of being run down into a regulus by elevating the temperature to a full white heat. The quantity of manganese reduced in this manner is principally dependent upon the high degree of temperature given to the metallic bath at that stage of the operation. For this reason, and also on account of the necessity to avoid an oxidising flame, the Siemens furnace is indispensable for this mode of manufacturing ferro-manganese. With all precautions, however, it is not possible to reduce all the manganese from the charge, and bring it down into the regulus. This is caused principally by the silica which is present in the mixture of ores or in contact with them during the operation. The affinity of the oxide of manganese for silica is so great that the reduction is almost entirely stopped so long as there is any free silica in contact with the manganese ore. The product of the combination is a liquid slag of a characteristic pale green colour, and which contains a very high percentage of manganese. The metal entering into this combination is, therefore, altogether lost for the metallic regulus, and only a part of it can be recovered by a subsequent utilisation of those slags in other processes.

With proper selection of materials the average proportion of the alloy obtained by this process is from 20 to 30 per cent. of manganese. A furnace of ordinary dimensions, and worked by one man, will produce about 15 cwt. of ferro-manganese every 24 hours. The principal element of expenditure is the cost of the carbonate of manganese, which is subject to considerable fluctuations. At the maximum quotation which this substance now commands in the market the cost of manufacturing one ton of the ferro-manganese of 20 to 25 per cent. is about 7l. independent of royalties;

but with improved experience, and by the further development of this process, the expenditure may in all probability be reduced very considerably in future.

The value of a rich alloy of manganese to the steel manufacturer is very great. For the manufacture of the softest kinds of steel, an alloy containing 15 or 20 per cent. manganese has, at one time, been considered an indispensable addition by many of our leading metallurgists. For this reason the price which steel makers used to pay for this alloy was very high. The rule laid down originally by Mr. Bessemer himself was to rate the ferro-manganese at 1*l.* per ton for every unit of manganese it contained. By this rate the value of the 25 per cent. metal would reach 25*l.* per ton. Commercial experience has, in the course of events, decided against this somewhat arbitrary mode of calculation; and the standard which is now put upon the value of ferro-manganese is taken from the actual pricc of Prussian spiegeleisen, and compared with the price of a mixture of ordinary hematite pig, with that quantity of ferro-manganese, which will bring the mass up to the same percentage of manganese as that held by the spiegeleisen. Taking, for instance, the price of spiegeleisen which averages 7 per cent. manganese, at 7*l.*, the equivalent mixture of hematite iron and ferro-manganese of 21 per cent., will be made up as follows:—

	£
Two tons hematite iron taken at 4*l.*	8
One ton ferro-manganese at	13
Gives three tons of metal of 7 per cent.	£21

It appears, therefore, that the commercial value of a 21 per cent. ferro-manganese, under ordinary circumstances in this country, must be taken at £13 per ton as a minimum. It appears equally obvious that the manufacture of these artificial alloys will be a suitable and remunerative industry, and will form a useful accessory to every Bessemer steel works in this country. The steel makers will obtain a better and more regular supply of spiegeleisen, and will make their works independent from all accidental fluctuations and inconveniences of the spiegeleisen trade, such as now exist between this country and the Liegen district.

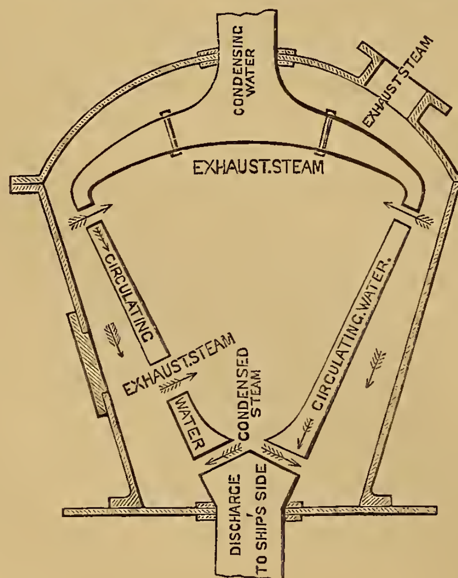
NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, AND INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.

ON A CONICAL SURFACE CONDENSER.

By Mr. Henderson.

Unfortunately there was not sufficieut time to read this important paper before the Institution. A short abstract of it, will, however, be of interest to our readers.

I consider this condenser to be much simpler in construction and more effective than the one in present use, by reason of its shape, as the whole jet of exhaust steam is brought to impinge instantaneously upon a large and unbroken surface, which causes immediate condensation; whereas,



with the tubular surface a very small portion of it is brought into immediate contact until the steam has passed down through the tubes, thus prolonging the process of condensation; hence the great quantity of surface required to cool the escaping steam to the necessary temperature. I have had this condenser constructed along with a tubular one—the cone representing 3ft. surface, and the tubular 15ft.—and have compared their respective efficiency, every other condition being kept alike for those models. After six different trials had been made, and an average of the results struck, I found that 1ft. of surface in the cone condensor was equal to 3½ft. of the tubular one. I have also had a trial of the cone condenser on board of a steamer with engines on the compound principle, cylinders 24in. and 48in. diameter. The top of cone was 5¼ft. diameter, and the bottom 16in., length over all 5ft. With this condenser a vacuum was formed at once, and got up rapidly to 25in., the engine working for fully 30 min. After that time the condenser got very hot. The engines, partly on that account, had to be stopped, but particularly on account of the unsatisfactory working of the circulating pump. The space in the inner vessel for the circulating water being small, every stroke of the pump causes almost a clean wash out, thus keeping the crown always cool, that being the place where all the work is done. With a condenser on this principle a great saving of original cost is effected, and it is much more easily overhauled, as by taking off the door at any time the whole condenser can be examined in two hours; whereas at present when the tubular condenser requires to be cleaned it takes from three to four days, and in many cases a fortnight. Again, the risk of leakage is greatly lessened from the very few joints in the cone condenser, these being only seven in number; whereas the tubular condenser contains many hundreds. The description given shows a few advantages in favour of the cone condenser, and I doubt not many more advantages will yet be discovered, and thus the construction of the marine engine greatly simplified.

SOCIAL SCIENCE CONGRESS.—MEETING AT NEWCASTLE.

WRECKS AND CASUALTIES.

By Henry Jeula, of Lloyd's.

The author read a brief memoir of the "Recent History and Present Position of Statistical Inquiry in relation to Maritime Disasters, and some Examples of Results already attained," with illustrated diagrams and an appendix. The paper opened with the remark that the magnitude of the maritime interests of Great Britain, her colonies, and of foreign States, might well induce the belief that the information relating to losses and accidents at sea, obtained at great pecuniary cost and constantly accumulating, would have been so carefully tabulated and arranged, that by this time fair and valuable deductions could be obtained from the facts accorded, but, instead of this, until very recently, the hope of any such useful results following the registration of wrecks and casualties was apparently considered altogether Utopian. The "Wreck Register of the Board of Trade" was mentioned as a most useful compilation, and reference was made to the "Bureau Veritas," in Paris, as publishing some interesting particulars relating to losses reported through that agency. An account was given of the "Statistical Committee of Lloyd's," formed in 1866, for the purpose of arranging a systematic registration of the marine casualties reported in the daily "Lloyd's List," showing that these are now classed under nineteen principal headings, with minor divisions, in addition to which the scheme includes, results to "ship" and to "cargo," the number of crews "saved" or "drowned," and "lives lost so far as reported." A geographical arrangement is added, consisting of thirty-one sections, grouped in four divisions, giving the voyages "to," "from," &c., with the results under six general heads, as "total loss," "minor damage," &c., &c., the whole so disposed that monthly, quarterly, half-yearly, and annual comparisons can be readily made. This committee had just issued its Fourth Annual Analysis, showing the casualties of 1869, in relation to the average of three previous years. The actual coincidence of some of the figures, to even a fraction, and the close approximation of many of the percentages, could scarcely fail to be remarked, and tended conclusively to show that maritime casualties, like other events, were under Divine Law, and could be rendered amenable to statistical research, and, ultimately, to scientific treatment.

The total number of casualties reported in 1869 was slightly in excess, being 11,606, as compared with the average of three previous years, 11,521, an increase of 85 in number or ·79 per cent. This was accounted for by steamers giving a considerable increase, sailing vessels showing a slight decrease, say 10,359 in 1869, against a three years' average of 10,453, a decrease of 94 in number or 90 per cent. Casualties to steamers, as already mentioned, showed a considerable advanoe, being 1 247 in 1869, as compared with an average of 1,068, an increase of 179 in the number, or 16·76 per cent. Diagrams and an appendix with various tables were added to illustrate the monthly variations. The first two quarters of 1869 gave a considerable reduction in casualties to sailing vessels, and the last two quarters a considerable increase; but steamers were in excess every quarter. The average annual number of losses posted on "Lloyd's Loss Book," for ten years ending 1866 inclusive was 3,443, being a decrease of 100 in number, or 2·90 per cent. Reference was made to the influence of increased rapidity in receipt of information, as shown in the comparative figures for different months, also to the greater equality of monthly proportion throughout the year relating to steamers over sailing vessels, and to total losses over minor casualties, which seemed to be indicated by the various diagrams and tables. The following classes of casualty showed a marked increase in 1869:—Collisions, missing ships, burnings, dismasted, &c.; jettison of deckload, &c.; ship damaged, loss of sail, &c., while several other classes gave a considerable decrease. The paper then referred to loss of life at sea, the returns relating to which were not so complete as could be desired, still, so far, they had been, encouraging, 1869 giving the number of crews saved from sailing vessels as 1,069, against an average of 686, an increase of 55·83 per cent.; from steamers, 59, in 1869, against an average of 29, an increase of 103·45 per cent.; while crews drowned were, in 1869, 52, the average being 44, an increase of only 18·18 per cent.; and the lives reported lost in 1869 were only 1,643, compared with an average of 1,703, a decrease of 3·52 per cent. Several comparative diagrams, and a copious appendix with tables, &c., accompanied and illustrated the paper.

THE TAMWORTH CATASTROPHE.

After about two years immunity from accident, the Irish Mail has again suffered fearfully although not so severely as at Abergele. The disaster happened at seven minutes past four on the morning of the 14th ult., at about 100 yards on the London side of the North-Western station at Tamworth. Here, it will be remembered, that line runs at a lower level than that of the Midland Company, whose station is immediately over that of the North Western. At the distance from the station we have indicated the London and North-Western passes over the river Trent upon a substantial brick bridge, with massive stone copings surmounting the brickwork on either side of the line. Terminating not far from the bridge at the Holyhead end, and upon the left hand of the line as the traveller's face is turned towards London there is a block siding, with its timber and earth buttress temptingly near to the river, but nearer still to a brick reservoir which the company have sunk in the ground, and keep charged with water for the supply of their engines. The line is, perhaps, 20ft. or 30ft. above the level of the river. In the event, therefore, of a train going along the siding and forcing a way through its buttress or end, the descent to the river would be very rapid.

After leaving Stafford the Irish mail has to stop nowhere till it arrives at Rugby. Its speed, therefore, as it passed through the station was probably about 60 miles an hour, for it was 17 minutes late when it left Stafford, and had made up a few minutes when it reached Tamworth. At this pace the train was shunted into the siding and ran headlong into the river. Of the fragile block at the end of the siding it took no heed, for it brushed away the uprights and its earth backing, and carried the curled-up rails along with it to the river's brink. Reaching the bed of the river, the fine engine ("Stephenson, 279") turned to the right, with its nose beneath the bridge; the tender assumed a nearly similar position; and mostly thrown on to the tender, but with a portion hanging over the stream, was the shattered body of a composite carriage, the wheels and the framework upon them remaining partly on the bank and partly on the nearest portion of the tender. A guard's van and two connected Post-office vans following were wrecked still more utterly than the composite carriage. Three other carriages made up the train. Of these three, the nearest to the engine had its end stove in, and its windows and other portions broken. The result of this frightful wreck was three killed, seven or eight severely wounded, and the rest terribly shaken.

As in most cases of this kind, the evidence given at the coroner's inquest was very unsatisfactory, but there was one fact which came out in evidence, that appears to us to account primarily for the disaster.

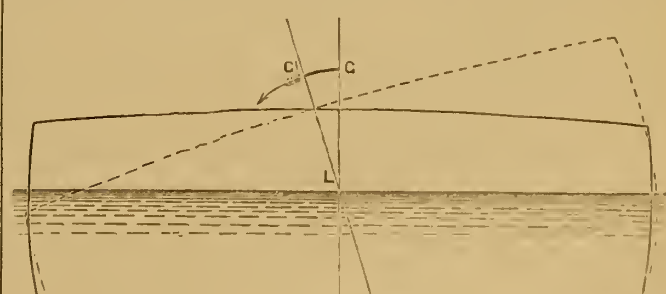
It was said, that the distance signal was at safety for the main line, but that the point signal was at danger, and this appears most probably to have been the case, as it is not likely the driver would have run past the distance signal when at danger; and as the points were open to the siding, the point signal for the main line would have been locked at danger. With a train travelling at 60 miles an hour the point signal would be useless to stop it in time, and it is therefore absolutely necessary that the distance signal should be controlled by the points as well as the point or station signal. Thus when the points are not right for the main line, the point lever should lock to danger both the main line station signal, and also the main line distance signal, when of course such an accident as this would have been avoided. Although a manager of an Irish railway, who was himself a sufferer, has said that in his opinion, the signal arrangements were, humanly speaking, perfect, we must beg to differ from him so long as the distance signal is not controlled by the point lever as well as the station signal.

THE LOSS OF H.M.S. "CAPTAIN."

The foundering of this noble turret ship, with all hands, except eighteen, is an event of such terrible importance that we cannot forbear to comment upon it, although the court-martial, or rather the scientific inquiry respecting the cause, has not yet been held. From the statement of the survivors it appears that it occurred about 12·15 a.m., on the 7th ult., the ship at the time being under double-reefed fore and main topsails, on the port tack, close hauled, with the wind about N.W. and very squally, with rain and heavy sea. About midnight the ship was felt making a very heavy roll to starboard, and at the same time a heavy sea struck her and threw her on her beam ends. She then turned bottom upwards, and eventually sank, going down stern first. From the time she fell on her beam ends to the time of sinking was about five minutes. Captain Burgoyne and a few of the crew swam to the steam pinnace, which was floating bottom up; shortly afterwards the second launch passed close to the pinnace, and Mr. May, the gunner, and two men succeeded in getting on board, but Captain Burgoyne failed in the attempt. After various unsuccessful efforts to save him and others, they were so nearly swamped that they found themselves forced to bear up, or the launch must have gone from under them. At this time there were nineteen persons in the launch, but one man was washed out of the boat by her shipping a heavy sea, which nearly filled her. There was no sail in the boat, and only nine oars. Mr. May knew that land was dead to leeward of the ship, and at daybreak they sighted Cape Finisterre. At last the weather moderated and they were able to land at Finisterre about noon of the 7th ult.

The following account from a survivor is very instructive:—"I heard the captain ask how many degrees she heeled. Heard answer, '18 degrees.' Thought the ship heeling very much. Tried to right, but would not. Went to weather netting, hauled myself along hurricane-deck to the main deck by the main tack, the ship being on her beam ends. Stood there a few seconds to see if the ship would right, and then as she turned gradually over walked over ship's bottom. My foot stuck in one of the valves in ship's bottom, and finally I stood upon the bilge piece, the seas closing over me. I came up to the surface, and the first thing I got hold of was a ropeyarn. I looked and saw the ship settling down by the stern; then saw launches, and struck out. When inside I felt the ship heel steadily over deeper and deeper, and a heavy sea strike her on the weather side; the water flowed in as I got through the pointing hole, only to find myself overboard. The last I saw of the ship was her prow; the whole time was but five to ten minutes, if so much."

From this it appears that the *Captain*, after heeling over 18 degrees, continued gradually to increase her angle of heel, or in other words, to roll over somewhat leisurely. The only way in which we can account for this is, that the centre of gravity was above the load water-line, and that at an angle of 18 degrees the point was reached at which the immersed side of the ship had lost all further power of resistance. The accompanying diagram will, we trust, make this sufficiently apparent. A midship section



of a vessel under the above conditions, and of similar dimensions to the *Captain*, is shown in full lines as floating upright. L being the height of the load water-line at the centre of the vessel, and G the position of the centre of its gravity. The position of the vessel when heeling over 18 degrees is shown in dotted lines, when it will be observed that the whole of the ship's side to leeward is immersed, and, consequently, that no further resistance to heeling can be offered by it. Again, when lying at this angle the position of the centre of gravity has changed to G', and as there is now nothing to hinder its downward course it will naturally revolve round the point

L, until it hangs vertically below it, or, in other words, it will turn the vessel bottom upwards. The question now arises, how can such a catastrophe be avoided in future if low freeboard ships are to be employed? The only conceivable answer to such a question is simply this:—Build the vessel of such proportions that the centre of gravity will be below the load water-line. Thus, if the weights of the vessel were so modified that the centre of gravity, instead of being at G, stood below the water-line at H, when the ship heeled over 18 degrees it would stand at H′. Here we perceive, that instead of pressing the vessel over, it exerts all its enormous influence to return to its vertical position H, and thus "right" the ship. In fact a ship having its centre of gravity above the line of flotation, and another carrying it below, are simple instances of unstable and stable equilibrium respectively, and it may, therefore, be taken as an axiom that a vessel with a low freeboard ought to have its centre of gravity below load water-line.

It would occupy too much of our space to go into the vexed question as to how a vessel can be built to satisfy this requirement, and yet be an easy and comfortable sea-boat and a good sailer, being perfectly aware that these conditions are to a great extent antagonistic. Moreover, it would scarcely be decorous to enter upon the question until the court martial is over, during which, no doubt, there will be a considerable amount of discussion upon this subject. We will only trust that the loss of a gallant commander, a picked crew, and the talented inventor of this system of naval architecture, which is undoubtedly the most formidable in existence, may not create such a panic as to lead to its abandonment, and thus reduce most materially, if not entirely, the supremacy of our navy.

THE INCREASING USE OF GLYCERINE.

A few years ago all the glycerine that was casually made in the soap, candle, and lard industry, was thrown away. At the present time it is carefully saved, and its applications have been so much extended that it has become a prime article of manufacture, and one that could not easily be dispensed with. Some of the uses are not popularly known, and it may be well to recapitulate them for the benefit of our readers.

The presence of glycerine in fermented liquors was proved by Pasteur ten years ago, and on this discovery was founded an artificial manufacture of wine which has since become a regular business. We have occasionally published paragraphs on the use of glycerine in sweetening wine, and have reason to suspect that much of the champagne of commerce owes its peculiar flavour to the presence of this foreign liquid. As it is not particularly deleterious to the system its use is a decided improvement on the custom of adding sugar of lead to wines and champagne practised in ancient times. After the discovery of glycerine in wine, attention was turned to other liquors, and it was found to exist in the best German beer in minute quantities as the result of a natural fermentation. This fact showed that in the fermentation of wort, besides the transformation of sugar into alcohol and carbonic acid, a secondary modification took place, called succinic fermentation, that is, the change of a part of the glucose into succinic acid and glycerine. We have never heard of the employment of succinic acid to improve the taste of beer, and are not likely to be troubled in this way on account of the great cost of the material; but the use of glycerine by brewers has now become an every day fact in Europe, and it is said to add to the keeping qualities as well as to the taste of beer. The quantity taken is small, amounting to from one half to one measure of glycerine to 100 measures of wort. A pound of glycerine costs at wholesale in Germany twenty cents, and it is said to go as far as two pounds of extract of malt. It is probable that for home-made beer and domestic brews of all kinds glycerine could be advantageously employed if the proportions could be popularly explained.

Another property of glycerine upon which many uses are now founded is the facility with which it dissolves a large class of bodies, and at the same time preserves them from alteration or decay. It dissolves aniline violet better than alcohol or acetic acid, and could be employed in dyeing with this colour.

Gum-arabic is soluble in glycerine, and the solution does not readily turn sour or become covered with mould. A somewhat similar action is shown towards albumen which it readily dissolves and keeps from decomposition. In both of these cases the solutions are useful in photography.

Another application in photography is to add a small quantity of glycerine to collodion to prevent too rapid drying. Such collodion is less sensitive, but admits of a longer exposure than the ordinary wet collodion, and is valuable in taking landscape pictures.

An addition of glycerine to paper in the manufacture of wall paper adds to the absorbing property of the surface, and prevents the spreading of the coloured patterns, without interfering with the drying qualities of the pigments. When mixed with litharge to a paste, glycerine forms an excellent cement for iron and stone, which becomes very hard and resists the action of most agents.

The much prized madder colors, alizarine and garancine, are soluble in glycerine and can be applied cold. The addition of water does not precipitate the colours, and boiling with alum and cream of tartar fixes them to woollen goods. The glycerine appears to extract the colours, and it is probable that in the case of wood and other dyes it is capable of a similar application.

In the manufacture of paper, when it is desirable to impart greater softness and elasticity, the glycerine can be mixed with the stock in the mill in the proportion of ten pounds of glycerine to two hundred pounds of stock. For copying and taking impressions the paper can also be immersed in a bath of seven parts glue to one part of glycerine.

Perhaps one of the most important applications of glycerine is in the preservation of meat from decay. For this purpose the sweet liquid ought to be thoroughly purified, so as not to impart any flavour to the flesh. As the pure glycerine requires a lower temperature to freeze it than mercury, the vessels containing the meat can be kept in very cold places. The same property of glycerine has been taken advantage of in collections of objects of natural history which are now immersed in it instead of in alcohol. The same preservative property is employed to keep medicines and many chemical compounds from premature dissolution.

Sculptors have found considerable difficulty in keeping their modeling clay moist, and to attain this object must have recourse to water. The admixture of glycerine has been found to be of great assistance, as it does not readily evaporate and holds the moisture a long time.

There are some articles of food that require to be kept in a moist condition, and this could be accomplished by the use of a small quantity of glycerine. It is also probable that bread could be kept from drying up or molding in the same way. It has long been customary to mix molasses, sugar, and extracts of roots with tobacco, and also to wrap up the packages in tin to keep the tobacco moist. Glycerine would serve a better purpose than any of the old substances without imparting any bad flavour to the tobacco.

The wet gas meter is a perpetual source of trouble in the winter, on account of the freezing of the water. This is remedied by mixing glycerine with the water, and thus reducing its freezing point to near zero.

As a lubricator for delicate instruments, such as watches, clocks, chronometers, etc., especially if they are likely to be exposed to sudden changes of temperature, there is nothing so good as glycerine. The best oils oxidize and become thick and require constant watching.

In the manufacture of copying ink glycerine has for some time been employed as a substitute for sugar and syrups; it also keeps the inks from moulding and decomposition.

A remarkable discovery was recently made that under certain circumstances glycerine could be fermented into alcohol. As the experiment was originally performed chalk and cheese (casein) were mixed with the glycerine at a temperature of 86° to 104° Fah., and left to react upon each other. It would be difficult to explain the reaction that took place, but there was no doubt about the formation of alcohol. A feasible way for making alcohol out of the sweet principle of oil would be an important discovery, and the further investigation of the subject is worthy the attention of chemists.

Mousseline weavers were for a long time compelled to carry on their work in damp cellars and unhealthy, ill-ventilated apartments; this evil is now overcome by the employment of a wash prepared out of dextrine, glycerine, sulphate of alumina, and water, and the workmen can drive their trade in the upper rooms of the house. The use of glycerine in the manufacture of a blasting oil is too well known to require anything more than a passing notice. Nitro-glycerine has become such an important article that to obtain it, special works for the manufacture of glycerine would be constructed rather than to dispense with its use.

The difficulty of observing the compass on board of screw steamers is increased by the agitation constantly produced by the machinery, and this has been obviated to a considerable extent by the employment of compasses swimming in a liquid prepared of glycerine and water. A capsule of crystal glass is substituted for the old copper basin, and in this way, as the liquid is transparent, observations can be made at night.

It has been found that the leather bands for machinery are much less likely to crack and break if they are soaked for a short time in glycerine after leaving the tanning vats.

When quicksilver is employed in the manometers of steam engines it is liable to oxidise and clog the tube. This evil is remedied by putting a few drops of glycerine on the top of the column of mercury, and thus preventing the contact of the steam and moisture with the metal. Glycerine is now employed as a substitute for oil and fat in extracting delicate perfumes from leaves and flowers, and in the preparation of perfumery and cosmetics as well as for hair oils.

Glycerine soap is an article that within a few years has been introduced into market in a liquid and solid form. The liquid soap is prepared by heating 100 part oleic acid, and 314 parts by weight of glycerine (sp. gr. 1·12) to 106° Fah., and adding 56 parts concentrated potash lye (sp. gr. 1·34) under constant stirring. This is an admirable soap for chapped hands and for cutaneous diseases and flesh wounds. The cost of the materials must prevent a large consumption of this article.

The addition of glycerine to glue has been highly recommended to prevent brittleness, and where gelatine is employed in the manufacture of artificial ivory, parchment paper, book-binder's stock, and the like. A paste composed of starch, glycerine, and gypsum retains its plasticity and adhesiveness, and can be recommended for luting chemical apparatus and in making plasters for pharmaceutical purposes. India-rubber for removing pencil marks is improved by the addition of glycerine glue.

Wood impregnated or washed with glycerine does not warp and dry up, and advantage is taken of this fact to keep butter tubs, water pails, barrels, and tanks from shrinking and leaking. Wood work exposed to the sun or heat of summer can be greatly benefited by occasional coats of glycerine. Moulds in which plaster casts are taken are now moistened with glycerine. A mixture of glycerine with a few drops of ammonia is used as a valuable remedy in the case of bites of venomous insects, and in medicine generally the employment of glycerine has become very extensive.

We have thus enumerated the chief applications of glycerine, enough to show that it has become one of our most valuable articles of manufacture. We are not in possession of the exact statistics, but from the rate of consumption it is easy to infer that the amount annually made must be very large, and it is probable as its properties become more generally known that the demand for it will go on increasing to meet the new applications that will be discovered for it. There are few articles of chemical manufacture of more value than glycerine.—*Scientific American.*

ON IMPROVEMENTS IN CANAL NAVIGATION.

By Professor Tilman (U.S.).

The canals and navigable rivers in the territory of the United States form a network of transit, unrivalled in extent and importance. In the State of New York alone the artificial water channels of communication have a total length of nearly one thousand miles, of which eight hundred and ninety-three miles belong to the State. The connections with rivers and small lakes make the whole distance now navigated by New York canal boats about 1,350 miles. On the twenty canals owned by the State are 565 stone locks, which if placed in a continuous line, would extend nearly seventeen miles; and the bridges over these canals, if placed end to end, would form a line of equal length. The Erie Canal, seventy feet wide and seven feet deep, is carried over several rivers and large streams on stone aqueducts of unequalled magnitude. Some idea may be formed of the business done on the New York canals by the following official statements:—From 1859 to 1866 inclusive, 12,850 canal boats were built and registered, having a carrying capacity of 1,291,497 tons. During those years the aggregate movement on all the canals amounted to 39,433,625 tons. For twenty years preceding 1867 the tolls collected amounted to 65,815,411 dols., the yearly average being 3,290,770 dols. After deducting the cost of maintenance, the average annual surplus revenue from the canals is found to exceed 2,319,500 dols. From 1854 to 1865, inclusive, the average freight paid for moving one ton one mile on the canals, was nine mills and one-tenth of a mill, while the average freight paid during the same time for moving one ton one mile on both the New York Central and Erie railroads, was 2 41-100 cents, showing that during those years the cost of transportation on railways was mostly three times greater than on canals. Boats carrying 210 tons burden are now used on the Erie Canal, the enlarged locks being eighteen feet wide and 210 feet long between the quoins. The boats are mostly moved by animal power, at a cost of thirty-eight cents each per mile, except on the river and lakes were they are taken in tow by steamboats. The average speed of canal boats of the largest class moved by horses does not exceed two miles an hour, and as only three horses can be employed with advantage to each boat, it follows that any further increase on the size of canal boats would involve a corresponding decrease in speed when moved by animal power. According to the able report for 1858 by the Hon. Van R. Richmond, New York State Engineer and Surveyor, the resistance to be overcome in moving a loaded canal boat at a speed of two miles per hour, calculated from Dubaut's formula, as modified by D'Aubisson, is 428lbs. The force required to develope the standard value of a horse-power at two miles per hour is 187½lbs.; deducting one-sixth for oblique action, leaves the force exerted in the direction of the boat's motion equal to 156¼lbs. From experiments made in France on the Lanquedoc Canal, it was found that ordinary horses exerted an average effort of 143½lbs. for six consecutive days, at a speed of two miles per hour. Consequently, an Erie Canal boat, which partakes of the general build of the Lanquedoc barges, would require three horses to move it at the rate of two miles per hour. The resistance of a vessel varies as the square of its speed, and the power to move it varies as to the cube of its speed. This law seems to have been overlooked by some of those who have attempted to move canal boats at comparatively high speed by means of steam power. They have recognised the truth of only a part of the proposition, namely, that the resistance varies at the square of the speed, that is to say, if a boat requires eight horses to overcome the resistance at four miles, to double its speed would require four times eight or thirty-two horses; yet is evident that this power must be applied while the boat is moving double the distance first made, therefore the number thirty-two must be doubled, which gives sixty-four horses as the measure of power required to move the boat at the rate of eight miles per hour. This law, however, cannot be strictly true for all forms of all vessels, and in navigating canals there are other conditions which modify the result, as, for instance, the wave of displacement which rising high in shallow water would seriously impede a vessel, but were its form so improved as to allow the water to commence closing in when only one-third of her length had passed, and were its speed at the same time increased to a certain point, this wave of displacement would be brought to such relative position that it would no longer impede the vessel. However, the carrying capacity of a canal boat being paramount, its form must not be modified so as to favour increased speed; thus, with this class of vessels the law will still hold good, to double the velocity the propelling power must be increased eight-fold. If a loaded canal boat is moved at the rate of two miles an hour with three horses and at the rate of four miles an hour with twenty-four, the obvious deduction is that is impracticable to move such boats by horse haulage at the rate of three miles per hour, and quite as impracticable to move them by steam at a speed greater than four miles an hour.

The plan of moving several canal boats by one steam tug is objectionable, because the whole moving power is concentrated at one place, and acts upon a very limited quantity of water. The same power divided into four equal amounts, and acting on four times the quantity of water would be more effective. Such boats are most liable to delays and are utterly helpless when detached from the steam tug.

The successful navigation of canals seems to me to depend on the following conditions:—

1. Each boat should be automatic, that is to say, self-propelling.

2. The build of the boat should be such as to give it the greatest carrying capacity.

3. To economise space and power, the boiler and engine should be small and capable of moving the boat when loaded at an average speed of three miles an hour. This rate is about double the present average of loaded boats.

4. The propelling power should act directly against the water and not against the bottom or sides of the canal.

5. If we turn to nature for lessons in propelling, we observe that the slow moving fish of our fresh water streams have broad tails bounded by nearly a vertical line, while those remarkable for speed have V shaped tails, the extremities of which are capable of very quick motion. Applying this principle to slow moving boats we infer that a quick motion is not so essential as a large average of propelling surface.

6. The width of the boat and its draft should only limit the quantity of water against which the propelling surface should act.

7. The boat should be made more obedient to the helm, by enlarging the rudder surfaces and arranging them so as to act on shallow water more efficiently than by the common method. The most important of these conditions would be fulfilled by building the boat with four sterns, and placing behind each a propeller; or giving the boat a scow-shaped stern, and arranging in one line behind it four screw propellers, placed nearly as deep as the water at the bottom of the boat, from which would project iron bars for their protection. The locks being 18ft. wide, the propeller blades could be nearly 4ft. 6in. in diameter, and whether the boat was light or loaded, these propellers would act on the water under the best possible conditions. Behind each of these propellers should be placed a balanced rudder, which, under these conditions, could be made one-fourth lighter than usual, and the tiller of each should be connected by a moveable joint, with one bar extending nearly across the boat, behind which the steersman can guide the boat by only exerting strength sufficient to overcome the friction of the apparatus. A boat embracing the improvements here suggested has not yet been constructed; but from careful estimates based on reliable data, I feel warranted in saying that such a boat when loaded could be moved at a speed of three miles an hour, with an expenditure not exceeding that now incurred in towing a similarly loaded boat at the rate of two miles an hour by means of horses. The saving thus effected would be between one and two million dollars per annum on the present business of the canal. A large portion of the carrying trade has been diverted from canals solely on account of the time consumed in transportation; we may reasonably infer that an acceleration of speed of about fifty per cent. would greatly increase the amount of goods transported by these cheap modes of conveyance, and thus correspondingly increase the revenue which the State derives from its canals.

BALLOONS FOR WAR PURPOSES.

The experiments made at Woolwich by balloons inflated at the Royal Arsenal gasworks have shown that a height of 100 fathoms, at a horizontal distance of 600 fathoms from an enemy, would enable the observers to secure a wide expanse of view. The balloons with which experiments were made at Woolwich were held by two new cords fastened to the network, and terminated at two different points on the ground, to give greater stability to the balloon, and to provide against one cord snapping, or being cut by the enemy's fire. By the new system of military telegraphy for field service, and by means of waggons at present being placed in store in the Royal Arsenal, lines of telegraph can be carried through the air from the earth several miles distant. The wire can be paid out as fast as the balloon travels, so that if a captive balloon should break away, communication could be kept up with it for six miles; or two or more balloons can be sent up, and kept in telegraphic communication with each other by means of similar lines, so that telegraphic operations can be made from the balloon to head quarters, and thence to the base of operations. By means of these new military telegraphic appliances the most rapid intelligence, and consequent speedy word of command, can be given. In sieges, war balloons are useful in giving information of depots, points of attack, batteries, inner intrenchments, the explosion of magazines in marshes, to spy out ambuscades that may be in waiting, to rally columns, and to telegraph points of assembly on attack. The observing officers were enabled to survey an area of thirty square miles. It was found that, by practice, great skill can be attained in judging of distances, and the relative position of masses of troops; while more minute details could be subsequently obtained at leisure by field-glasses as to the position of mountain gorges, passes, limits of woods and the course of streams. The trials hitherto made have been chiefly carried on by professional aeronauts with hired balloons; and it is believed that the British Government have at the present time no war balloons in store. The result of the observations of Captain Brackenbury and Captain Noble, sent out from Woolwich on behalf of the English Government to the respective seats of war, together with trials and other sources of information, will, it is believed, result in war balloons being manufactured in the Royal Arsenal, and that officers of Royal Engineers, from Generals downwards, will be trained in their use.

REMOVAL OF THE REEF AT HALLETT'S POINT, NEW YORK.

Subjoined is the report of the superintendent of the mining operations being carried out upon this difficult work:—

"The Government, well aware of the necessity as to the ultimate removal of these obstructions, and of creating a clear draught of from twenty-five to thirty feet, intrusted the carrying out of important works to the engineer in charge, Major-Gen. John Newton, who decided, in reference to Hallett's Point, upon the following plan:—The situation of the reef suggested, naturally, the idea of attacking the rock at his base by mining operations, which method has been applied and carried out in England, Scotland, and Egypt, with the most satisfactory results. To accomplish the object in view, the engineer in charge ordered a shaft to be sunk on the shore line, at Hallett's Point, of the following dimensions:—Length, 115 feet; cross-section, 95 feet; datum line, 30 feet below mean low water. From this floor line of thirty feet below mean low water, eight respective headings or tunnels are now being driven under the East River, of the following dimensions:—From 120 to 200 feet forward, the gallery of the first curve will be struck. The object of these galleries is to connect all the respective headings, producing thereby what is technically called the cellular system. On reaching the length of 100 feet forward with the headings, a similar second gallery will be struck, and, on reaching a further length of 150 feet, the gallery of the third curve will be struck, when ultimately the powder-chambers will be cut into the respective piers left standing, in order to operate in a uniform resistance of thirty feet overhead and twenty-five feet lateral. In penetrating under the river, careful tabular calculations are daily prepared by testing the density of the stratified rock, which investigations are required to secure positive results from the intended grand explosion, by which the formidable obstructions will be lifted from their solid base, and broken into fragments of convenient size, to a depth of 30ft. Excepting a slight elevation of the upper strata of the water, and a gentle trembling in the knees of the observer, the effect of the intended grand explosion will hardly be perceptible to the public. No detonation whatever will be heard; no anticipated breaking of windows and crockery in adjoining households will be experienced. These facts are corroborated in the British Parliamentary records and the European professional papers, which are annually published, and prove that more than 400 similar operations, with charges of from eight to 21,000 pounds of powder, have been calculated and fired by the writer of this article, without doing damage to one dwelling or endangering the life of a single individual. On this occasion, during seven years of operation, 650 tons of powder have been used, of which 200 tons have been furnished from the Oriental Powder-works, in this country, through which means 4,000,000 cubic yards of the hardest crystalline amorphous schistose rock have been successfully lifted from their base-line."

Opening of The New Blackwall Railway.—The North London Railway Extension to Blackwall was opened for passenger traffic on the 3rd ult. By means of this extension passengers from the northern suburbs to East India Dock, and the Ramsgate, Margate, and Gravesend steamers, will avoid the inconvenience of going round to Stepney to change carriages, and will run direct to the old Blackwall station.

NOTES AND NOVELTIES.

MISCELLANEOUS.

At the last meeting of the Hackney District Board of Works, Dr. Tripe, the medical officer of the district, reported that he had visited a factory belonging to a Mr. Barnes, at Hackney Wick, where was a furnace fitted up for burning "dead oil"—that is to say, an oil which is given off during the latter stages of the distillation of gas tar. The oil, however, burnt at Mr. Barnes' works he discovered was not "dead oil," but a similar product, which is pumped up with water from a deep well in the factory, and resembled impure rock oil. He believed it was the only instance of a natural oil spring known in England. It was very probable that an offensive smell was given off at times from this furnace, as, unless constant care were exercised, too large a quantity of the oil might be carried into the furnace fire, and part of it pass off unburnt.

The works in connection with the A. B. C. process of purifying and utilising the sewage have been commenced by the Leeds corporation near the sewage outfall on the river Aire. It is expected that they will be completed in about three or four months.

Black Mountain, North Carolina.—In speaking of this, Professor Kerr, the State geologist, remarks:—"These rocks belong to the most ancient of the azoic series. The intensity of the metamorphism, the characteristic rocks and their contained minerals, together with the total absence of anything like organisms in even the least altered and latest of the series, render this conclusion inevitable. And not only do they belong to the lowest geological horizon, but the entire absence of all representatives of the latter formation makes it further necessary to conclude that we have here an extensive tract of the oldest land on the globe."

It is reported that the Hoosac Tunnel is now progressing at the rate of 10ft. a day—4ft. from the west end, and 6ft. from the east end. The central shaft is complete; its depth to the floor of the tunnel is 1,030ft. Work at the new headings is already begun. The tunnel has been excavated 11,765ft. at both portals, that is, 6946ft. at east side, and 4,819ft. on the west side.

NAVAL ENGINEERING.

The tenders of the four following firms for the building of the four ironclads ordered by the Admiralty have been accepted, viz., Messrs. J. Elder and Co., Messrs. Caird and Co., Messrs. Palmer and Co., and Messrs. Dudgeon and Co.

Messrs. Rennie, shipbuilders, of Greenock, have taken a contract with the Admiralty for the construction of two ironclad gun vessels, similar to the *Snake* and *Scourge*, which are now building in Chatham Dockyard.

The British Government have contracted with Messrs. John Elder and Co., for the construction of an armour-clad, having two revolving turrets, to carry guns of the largest calibre. The Government seem now determined to increase the national defences, and that with the greatest rapidity, as the above firm have engaged to complete this armour-clad in fifteen months.

On the 6th ult., the first armour-plate of 12in. thickness, supplied by Sir John Brown and Co., Atlas Works, Sheffield (Limited), to the Admiralty as armour for Her Majesty's ships, was tested on board the Admiralty armour-proof ship *Nettle*, in Porchester-creek, Portsmouth harbour. The dimensions of this extraordinary piece of rolled iron plating, which weighed nearly 15 tons, were 14ft. in length, 5ft. in breadth, and 12in. in thickness. The new system of test adopted by the Admiralty for proving thick armour-plates—the substitution of Palliser shot fired from the 7-in. muzzle-loading rifled gun for spherical cast-iron shot fired from the smooth-bore 8-in. gun—was followed on this occasion. The powder-charges used were each 21lbs., and the distance between the muzzle of the gun and the face of the plate was 30ft. Four shots fired under these conditions struck within a radius of 11in., producing indentations varying from the *minimum* depth of 6·3in. to the *maximum* of 7·56in. Beyond the detaching of a small piece of the outer mould and a few radial cracks of a very trifling character around the indents, the plate sustained no superficial injury, the metal displaced by the entrance of the projectiles being absorbed into the body of the plate and producing a bulge on the back of the plate of rather less than one inch in height. The plate, in fact, passed through its proof with remarkable success.

SHIPBUILDING.

Messrs. Caird and Co., Greenock, have contracted to build another steamer of 3,500 tons for the Peninsular and Oriental Steamship Company. Her engines, which will be 600 horse-power, are also to be provided by Messrs. Caird and Co. The dimensions of the new steamer will be 380ft. in length, 42ft. beam, and 36ft. depth of hold. Messrs. Caird and Co. have other two steamers of similar dimensions in course of construction for the Peninsular and Oriental Company.

LAUNCHES.

On the 7th ult., there was launched from the shipbuilding-yard of Messrs. John Elder and Co., the *Volta*, an iron screw steam-ship of 1326 tons B.M., and 250 horse-power nominal, and of the following dimensions:—Length between perpendiculars, 278ft.; breadth, moulded, 31ft.; depth of hold, 14ft. 7½in.; height 'tween decks, 8ft. 6in. The *Volta* has been built to the order of the British and African Steam Navigation Company, of Glasgow, and is intended for their trade on the west coast of Africa. She is the third vessel which the owners have had launched from Messrs. John Elder and Co.'s yard this summer.

Messrs. John Elder and Co., launched from their shipbuilding-yard at Fairfield, Govan, an iron screw steamship 3,200 tons, B.M., and 500 H.P., nominal, and of the following dimensions:—Length between perpendiculars, 370ft.; breadth 41ft.; depth, moulded to spar deck, 36ft. 9in. As she left the ways she was gracefully named the *John Elder*, by Miss Just, daughter of William Just, Esq., managing director, Pacific Steam Navigation Company of Liverpool. The figure-head of the vessel, which, along with the entire carving work, was executed by Messrs. Kay and Reid, Wellington-street, evoked the favourable comment of the spectators, being a remarkably faithful likeness of the late proprietor of the Fairfield establishment, after whom the vessel is named. The *John Elder* has been built to the order of the Pacific Steam Navigation Company, and is intended for their fortnightly service between Liverpool and Valparaiso *via* Straits of Magellan. The builders have five steamships on hand for the same owners, viz., the *Cuzco, Chimborazo, and Aconcagua*, sister ships to the *John Elder*, and the *Atecama* and *Coquimbo*, steamships of 1,975 tons and 350 horse-power nominal.

Launch of the Cunard Liner "Parthia."—This splendid vessel was launched on the 10th ult., by Messrs. William Denny and Brothers, from their building yard at Dumbarton. The *Parthia* is one of four vessels of the same large dimensions, which have lately been fitted out on the Clyde for Messrs. Burns and MacIver's great fleet of Atlantic steamers, and these four vessels will each afford carrying accommodation for upwards of twelve hundred people.

ON the 8th ult., there was launched at Pointhouse, from the shipbuilding-yard of Messrs. A. and J. Inglis, two iron clipper schooners of 155 tons each, named the *Elena* and *Teresa*, built to the order of Messrs. M'Crindell, Schaw, and Co., Glasgow, for their South American trade.

THE London and Glasgow Engineering and Iron Shipbuilding Company launched from their yard at Govan a screw steamer of 1,500 tons, and of the following dimensions:—Length, 252ft.; breadth, 32ft.; depth of hold, 16ft. She is built to the order of Messrs. J. A. Dunkerly and Co., Hull, and is the fourth steamer supplied by the company to that firm, for whom they have also a sister ship at present on the stocks. The ceremony of naming the vessel the *Trent*, was performed by Miss Fowler, daughter of Captain Fowler, senior captain of Messrs. Dunkerly and Co.'s fleet. We believe this vessel is intended for the India and China trade *via* the Suez Canal.

RAILWAYS.

A SECOND line of Liverpool street railway was publicly used for the first time on the 2nd ult. It passes from the Exchange to Stanley Park through Scotland-road, one of the largest and most crowded thoroughfares of the town.

THE direct railway line from Ayr to Mauchline was opened on the 1st ult., for passenger traffic. The new line is about eleven miles in length, and will be a great convenience to those living in the neighbourhood of the route. Mauchline by the road is only ten miles distant from Ayr, and some idea of the value of such a line as the one now opened will be formed when we state that under the old railway system all the traffic between the two places had to be conducted over nearly thirty miles of railway.

CANADA.—Considerable progress has been made with the works of the Toronto and Nipissing railway, and large quantities of rails and other materials have been accumulated. The directors hope to have trains running over a portion of the road in the course of this month.

DOCKS, HARBOURS, BRIDGES, &c.

PLANS of a proposed Eastern Ganges Canal have been despatched to the Viceroy at Simla, by the Government of the North-Western Provinces of India. This project, upon which a staff of engineers has been engaged for some time, contemplates a canal from the Ganges, to commence about ten miles below Hurdwar, and to irrigate a large tract of country—over 3,000 square miles—in the districts of Bijnour, Moradabad, and Budaon. The total length of the main canal and branches, as projected, would be upwards of 1,000 miles.

TELEGRAPHIC ENGINEERING.

EXPERT operators are able to transmit from fifteen to twenty words per minute through the Atlantic cable. The velocity with which a current or impulse will pass through the cable has been ascertained to be between 7,000 and 8,000 miles per second; the former being the velocity when the earth forms a part of the circuit, and the latter when it does not.

TELEGRAPH TO JAMAICA.—Telegrams from Sir Charles Bright announce the completion of the Cuba Company's submarine cable, connecting Havannah, by way of Batabano, with Santiago, at the other extremity of the island, a distance of nearly 600 miles, and also that he has successfully laid the first section of the chain of West Indian cables between Cuba and Jamaica, placing that island in communication, through the United States, with England. The arduous nature of the first portion of the work will be shown by the fact that the first hundred miles from Batabano had to be laid in very shallow water, ranging from two to three fathoms, the cables being transhipped to lighten a very tedious work. The great weight of the cable used in this section also involved much manual labour. Sir C. Bright's next operation will consist in laying the further sections of cable from Jamaica, through the whole chain of the West India islands, to Demerara, and also a long branch from Jamaica to Panama, to bring upon the system the traffic centering there from Lima, Callao, Valparaiso, and other important places on the western coast of America. The various islands have agreed to give annual subsidies for the maintenance of the communication, the total length of which will be 3,530 miles. The cables are manufactured by the India-rubber, Gutta-percha, and Telegraph Works Company, Silvertown.

APPLIED CHEMISTRY.

M. MARIX has taken, in France, a patent for the application of fluosilicic acid for the purifying of beetroot, and other saccharine juices. The saccharine fluids are first diluted with a sufficient quantity of water to take away the viscosity of these fluids, sufficient fluosilicic acid is then added to precipitate all the potassium salts present, and next chalk is then added to saturate any excess of the acid. The fluid is then filtered in order to obtain a clear liquid, and this afterwards treated in the usual manner.

MR. WM. H. CHANDLER, of the Columbia School of Mines, proposes, for the determination of small quantities of lead, to evaporate the water with about two fluid ounces of acid solution of acetate of ammonia—this re-agent prevents the separation of the sulphate and carbonate of lead during evaporation. After concentration any iron and lime salts that may fall down can be removed by filtration. If any lead be present it can be precipitated in the usual way by sulphuretted hydrogen, and may afterwards be converted into the sulphate.

CHLORINE ON ALCOHOL IN SUNLIGHT.—G. Streit and B. Franz passed a current of dry chlorine gas into absolute alcohol with a view to the preparation of chloral. The current of gas being lively, the temperature of the alcohol rose soon to 155 deg. F., where it remained constant. During this time a beam of sunlight accidentally struck the flask which contained the alcohol. An immediate detonation took place, which continued under the influence of the light, the gas bubbles exploding with a weak report and a flash of light as soon as they entered the alcohol. The light reached in several cases two or three inches up into the connection tube. The alcohol blackened at the same time, depositing after a while a black powder, probably carbon.

ANTHRACINE.—This hydro-carbon is obtained from the dense portions of coal tar, by repeated distillation, pressure, recrystallisation from benzine and sublimation. If the anthracene has not its proper melting point of 210 deg. to 213 deg., it must be recrystallised until it melts at this temperature. Thus obtained, it is in crystals, to which a bright yellow coloration tenaciously clings. They can be freed of this, however, by sublimation at the lowest possible temperature and subsequent washing with ether; or by bleaching a solution in hot benzine by direct sunlight. In the last the anthracene separates on cooling in colourless crystals, of a superb blue fluorescence. These crystals are tubular, smaller or larger according to the degree of purity, and belong to the monoclinic system. If coloured at all yellow—the colouring substance is chysogene—the beautiful blue fluorescence above alluded to, is not seen upon them. Anthracene is soluble with difficulty in alcohol and ether, easily in boiling benzine. It melts at 213 deg., and distils 360 deg.

LATEST PRICES IN THE LONDON METAL MARKET.

	From			To		
	£	s.	d.	£	s.	d.
COPPER.						
Best selected, per ton	72	0	0	73	0	0
Tough cake and tile do.	70	0	0	71	0	0
Sheathing and sheets do.	73	0	0	,,	,,	,,
Bolts do.	75	0	0	76	0	0
Bottoms do.	76	0	0	77	0	0
Old (exchange) do.	63	0	0	,,	,,	,,
Burra Burra do.	70	0	0	71	[illegible]	0
Wire, per lb.	0	0	10	,,	0	,,
Tubes do.	0	0	11	,,	,,	,,
BRASS.						
Sheets, per lb.	0	0	8¼	0	0	0
Wire do.	0	0	7¼	,,	,,	,,
Tubes do.	0	0	10	,,	,,	11½
Yellow metal sheath do.	0	0	6½	0	0	7
Sheets do.	0	0	6¼	,,	,,	,,
SPELTER.						
Foreign on the spot, per ton	18	0	0	18	10	0
Do. to arrive	,,	,,	,,	,,	,,	,,
ZINC.						
In sheets, per ton	24	0	0	,,	,,	,,
TIN.						
English blocks, per ton	123	0	0	124	0	0
Do. bars (in barrels) do.	125	0	0	,,	,,	,,
Do. refined do.	128	0	0	,,	,,	,,
Banca do.	126	0	0	,,	,,	,,
Straits do.	124	0	0	,,	,,	,,
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	5	0	1	8	0
IX. do. 1st quality do.	1	11	0	1	13	6
IC. do. 2nd quality do.	1	6	6	,,	,,	,,
IX. do. 2nd quality do.	1	12	6	,,	,,	,,
IC. Coke do.	1	2	6	1	3	6
IX. do. do.	1	8	6	1	9	6
Canada plates, per ton	13	10	0	14	10	0
Do. at works do.	13	0	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	7	6	,,	,,	,,
Do. to arrive do.	7	5	0	,,	,,	,,
Nail rods do.	7	10	0	,,	,,	,,
Do. Stafford in London do.	8	5	0	9	0	0
Bars do. do.	8	0	0	9	0	0
Hoops do. do.	8	15	0	9	0	0
Sheets, single, do.	9	10	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	0
Bars, common, do.	6	15	0	,,	,,	,,
Do. mrch. Tyne or Tees do.	6	10	0	,,	,,	,,
Do. railway, in Wales, do.	7	0	0	7	5	0
Do. Swedish in London do.	9	15	0	9	17	6
To arrive do.	9	15	0	,,	,,	,,
Pig No. 1 in Clyde do.	2	12	0	3	0	0
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. No. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	17	0	6	0	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pig in London do.	6	5	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	13	10	0	13	15	0
Do. (hammered) do.	14	5	0	14	10	0
Do. in faggots do.	15	10	0	,,	,,	,,
English spring do.	17	0	0	23	0	0
QUICKSILVER, per bottle	8	8	0	,,	,,	,,
LEAD.						
English pig, common, per ton	18	10	0	19	10	0
Ditto. L.B. do.	19	0	0	,,	,,	,,
Do. W.B. do.	20	10	0	21	0	0
Do. sheet, do.	20	10	0	21	0	0
Do. red lead do.	21	10	0	,,	,,	,,
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	22	0	0	,,	,,	,,
Spanish do.	18	0	0	,,	,,	,,

* At the works 1s. to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of 'The Artizan."

Dated August 26th, 1870.

2342 T. E. Mullock—Fire-arm barrels
2343 A. Hill—Horse shoes
2344 F. Gray—Gas lamps
2345 G. E. Morgan—Facilitating the teaching of music
2346 J. Morrell—Mode of preserving bacon, &c.
2347 G. Ritchie, and J. G. Ritchie—Umbrellas, &c.
2348 W. Riddle—Saving life from fire
2349 T. F. Henley—Tunnelling or forming galleries.
2350 T. Lacey and S. C. Lacey—Stopping the flow of gas

Dated August 27th, 1870.

2351 C. Duff—Paper pulp for paper
2352 J. S. Linford—Construction of hydrometers
2353 H. J. Haddan—Tunnelling
2354 T. Clayton and W. H. Bailey—Inflammable gas
2355 G. S. Hazlehurst—Looms for weaving
2356 W. Tongue—Combining fibrous materials
2357 G. Gore—Omnibuses, &c.
2358 W. R. Lake—Ornamenting dresses
2359 W. R. Lake—Tacks, &c.
2360 T. Restell—Fire-arms

Dated August 29th, 1870.

2361 E. Chiverton—Lamp-lighter
2362 R. Mackay—Aerated beverages
2363 E. T. Hughes—Freezing apparatus
2364 W. R. Lake—Paper bags
2365 W. N. Lindsay—Hay, &c.
2366 J. C. Simonds and R. Donnison—Oil from seeds
2367 M. Gray and F. Hawkins—Marine telegraph cables
2368 W. E. Newton—Lithographic printing machines
2369 A. Noble—Torpedoes

Dated August 30th, 1870.

2370 F. Coombes—Stoppers for bottles, jars, casks, &c.
2371 S. Boucher—Spinning textile matters
2372 D. Pidgeon and W. Manwaring—Cutting apparatus of reaping and mowing machines
2378 J. J. Bodmer—Iron and steel apparatus
2374 F. Grosvenor—Pottery and machinery apparatus
2875 W. T. Guyatt—Trade mark labels, &c.

Dated August 31, 1870.

2376 J. Ingham—Table-forks
2377 T. Atkins—Heat and gases from furnaces
2371 J. Adair—Bakers ovens, &c.
2279 O. Gjerdrum—Smoke-preventing apparatus
2380 W. R. Oswald—Steam engines.
2381 A. M. Clark—Sewing-machine apparatus

Dated September 1st., 1870.

2382 C. Morfit—Improved alloy or metal
2383 I. Baggs—Steam and gas engines
2384 C H. Chadburn and W. Chadburn—Mechanical telegraphs, &c.
2385 W. R. Lake—Railways, &c.
2386 A. Turner—Printing yarns, &c.
2387 W. Donisthorpe, W. Leatham, and G. E. Donisthorpe—Coal machinery
2388 G. Haseltine—Horse apparatus

Dated September 2nd., 1870.

2389 W. C. S. Percy—Clay apparatus, &c.
2390 J. Marshall and H. J. Harman—Railway chairs
2391 E. Seyd—Medical plasters
2392 B. Hunt—Wool machinery
2393 C. Henderson—Girders, iron &c.
2394 C. Whellams—Shield or mantelet
2395 J. Lewthwaite—Marking apparatus
2396 H. and A. Holmes—Wheels
2397 G. Haseltine—Puddling furnaces
2398 J. W. Girdlestone—Dry closets &c.
2399 E. A. Parnell—Soda
2400 R. Leighton—Gilding
2401 W. R. Lake—Caustic soda and potash
2402 A. M. Clark—Looms

Dated September 3rd, 1870.

2403 T. Rogers—Tucking gauge and marker
2404 S. Meredith—Puddling and balling furnaces
2405 J. Neale and J. B. Fernby—Lamps to carriages
2406 W. J. E. Priestley and J. Forsythe—Hackling machines
2407 S. Dawson and E. Davies—Silk bolter apparatus
2408 H. Fontaine—Match boxes
2409 G. Haseltine—Shafting
2410 G. Haseltine—Fabrics
2411 G. Haseltine—Pressure-gauge and alarm apparatus

Dated September 5th, 1870.

2412 M. Henry—Piers, docks, &c.
2413 R. M. Merryweather—Fire-engines
2414 W. E. Newton—Steam boilers
2415 W. E. Newton—Loaf sugar machinery

Dated September 6th, 1870.

2416 W. Walker—Propellers, pumps, and blowers
2417 B. Hunt—Wool-washing machinery
2418 A. McNeil and William Wheaton—Salts and ammonia
2419 A. V. Newton—Construction of lubricator
2420 C. Bottom, J. Hallam, and S. W. Hallam—Hardening machinery, &c.
2421 D. Payne—Improvements in printing machinery
2422 T. M. Gladstone—Chimney tops and ventilators

Dated September 7th, 1870.

2423 E. Edwards—Nitrous oxide apparatus
2424 A. Noble—Fuzes
2425 C. Morfit—Fertilizers
2426 C. W. Moaley—Gas burners
2427 G. Haseltine—Type manufacturing.
2428 J. Banks—Casement fasteners

Dated Sepeember 8th, 1870.

2429 W. Silcock—Malt and drying kilns
2430 J. Eastwood—Steam boiler heating apparatus
2431 M. Lawson—Wearing apparel
2432 W. Clough and T. Child—Tilting barrel apparatus
2433 J. H. Johnson—Rod joints
2434 T. T. Prosser—Tube cutter
2435 E. R. Southby—Mineral oils
2436 L. Perkins—Locking gear

Dated September 9th, 1870.

2437 G. H. Ellis—Gas and air engines
2438 T. Burt—Machinery
2439 T. Bell, W. W. Urquhart and J. Lindsay—Power looms
2440 J. Tildesley—Locks and latches
2441 T. H. Blamires—Carding wool
2442 J. Kellett—Locks and latches
2443 J. T. Griffin—Reaping and mowing machines
2444 W. R. Ninipple—Caissons, bridges, &c.
2445 G. A. Huddart—Railways
2446 J. J. Barnett—Fabrics

Dated September 10th, 1870.

2447 W. B. Turner—Winding
2448 H. Tristram and E. G. Leeman—Letter boxes
2449 F. Mills and T. A. Scholfield—Goffering fabrics
2450 J. W. Rhodes—Tobacco pipes
2451 A. Stolipine—Lighting
2452 W. E. Bartlett—Elastic tyres
2453 G. H. Carter—Paddle wheels
2454 T. Westhorp—Fibrous materials
2455 G. Hurdman and S. Simkins—Stew pans, &c.
2456 H. Fairbanks—Weighing machines
2457 A. Mason—Paper bags

Dated September 12th, 1870.

2458 T. Harvey—Distilling
2459 C. Stephens—Firebars
2460 A. Taylor—Closets
2461 J. Lancaster—Sizing machines
2462 T. N. Kirkham, V. F. Ensom and G. Spence—Fibrous materials
2463 A. V. Newton—" Gatling " gun

Dated September 13th, 1870.

2464 G. Baldock, T. J. Denne and A. Hentschel—Casting blocks, &c.
2465 E. Lord—Fabrics
2466 G. Well—Earth screws
2467 W. Tilson—Twist-lace machines
2468 E. L. Parker—Fastenings for braces, &c.
2469 H. Deacon—Chlorine
2470 T. Routledge—Paper

Dated September 14th, 1870.

2471 R. Thompson—Dovetail mortises, &c.
2472 T. Onion—Measuring the flow of water
2473 J. Large—Stoves
2474 L. W. Broadwell—Revolving guns, &c.
2475 J. H. Glew and S. H. Lewis—Bench for boot and shoemakers, locksmiths, &c.
2476 H. Deacon—Chlorine
2477 W. E. Newton—Fastening for garments
2478 J. B. Spence—Alum
2479 S. Rolfe—Harmoniums
2480 A. Liverstone and S. Solomons—Hats, &c.

Dated September 15th, 1870.

2481 G. Rothnie—Self-indicating thermometers
2482 W. Snaydon — Two-wheeled carriages
2483 T. P. Young and J. Thomasson—Looms
2484 J. J. Eustace and J. B. Spearing—Railway Carriages
2485 E. Edwards—Photo-mechanical printing
2486 G. Haseltine—Microscopic apparatus
2487 J. Ccurtis—Handles to scoops
2488 G. Lucas—Looms
2489 J. Hamilton and R. Paterson—Fires
2490 I. A. Timmis—Brattice cloths
2491 H. E. Towle—Electro-plating
2492 W. E. Newton—Bunches or fillers for cigars
2493 V. Batchelor—Reclining chairs and couches

Dated September 16th, 1870.

2494 W. Boggett—Machinery for cutting and shaping slate
2495 E. Howarth—Connecting the ends of straps or belts
2496 H. Patterson — Steam boilers or generators
2497 I. Haigh, J. Haigh and I. Haigh—Waterclosets
2498 W. R. Lake—Life-boats
2499 J. Atkins—Suspending pictures, &c.
2500 F. Edwards—Patterned fabrics
2501 P. Murray—Pulley blocks
2502 H. J. Williams—Machine for cutting mill-boards

Dated September 17th, 1870.

2503 T. Platt—Construction of railway axles
2504 F. Kohn—Specific gravity
2505 T. Walton—Ventilating rooms or buildings
2506 E. Kidd and G. Bourne—Water gauge
2507 G. White—Propeller for steam navigation
2508 H. E. Towle—Forming wire into spiral coils
2509 W. E. Newton—Wood paving
2510 J. B. Stoner—Fittings for saving life in water
2511 G. W. Murray and G. M. Garrard—Apparatus employed in ploughing and tilling land
2512 W. A. Marshall—Earth-boring apparatus

Dated September 19th, 1870.

2513 J. K. Field—Candles
2514 E. S. Norcombe—Letter-press printing machines
2515 P. Jones — Ornaments known as "plateaux"
2516 G. Bischof—Purification of water
2517 H. Harris—Filtering
2518 W. Kempe and A. Kempe—Raising the pile on woolen and other cloths
2519 F. J. Bugg—Artificial leather
2520 C. Bogaerts—Obtaining greese and oil from soapy and greasy water
2521 A. H. Brandon—Gas burners

Dated September 20th, 1870.

2522 A. Frankerberg—Cooling apparatus
2523 R. L. Haworth—Looms
2524 M. D. Hollins—Metal plates
2525 J. B. Elkington—Telegraph wires
2526 T. E. Bond—Sweetmeats and lozenges
2527 J. A. T. Overend—Setting machines
2528 D. H. Brandon—Cut-off valve gear for steam engines
2529 J. Couper, W. H. Richardson—Lamps

Dated September 21st, 1870.

2530 J. Raywood—Ironing
2531 W. Harvey—Riding saddles
2532 T. Rose and R. E. Gibson—Cotton machinery
2533 W. J. Barron and E. C. Barron—Leather machinery
2534 F. Fenton—Sewage utilization
2535 H. H. Bigelow—Boot heeling
2536 H. H. Bigelow—Boot heels
2537 A. M. Clark—Rolling mills
2538 I. Bailey—Wool-combing machines
2539 S. S. Brown—Lint apparatus
2540 E. Pettitt—Spinning
2541 D. M. Childs—Sewing machine needles
2542 B. Walker and J. F. A. Pflaum—Driving wheels
2543 T. B. Daft and C. E. Crawley—Tunnels and tubes
2544 G. T. Bousfield—Oils and petroleum
2545 J. More—Cutters of the 'Woodworth'
2546 H. Jones—Twine and cord holder

Dated September 23rd, 1870.

2547 H. Senoch—Writing machine
2548 W. Bywater and J. Shaw—Drawing, spinning &c.
2549 T. Rawsthorne—Spinning
2550 D. M. Weston—Machines
2551 A. Barclay—Furnaces
2552 P. Gaskell and H. Moon—Cabs
2553 G. E. Marchisio and E. Stevens—Oil
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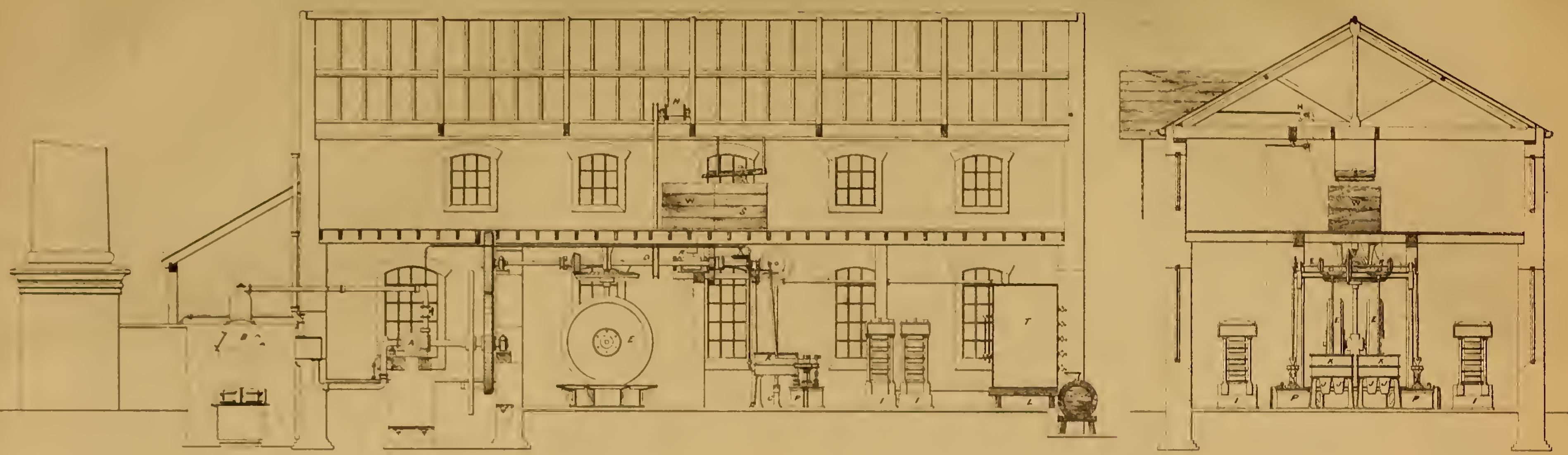
2556 C. F. Carter—Embossing presses
2557 J. T. Rich—Boilers, &c.
2558 J. P. Ferris—Valves
2559 P. Koch—Tapping nuts
2560 W. R. Lake—Rasps and files

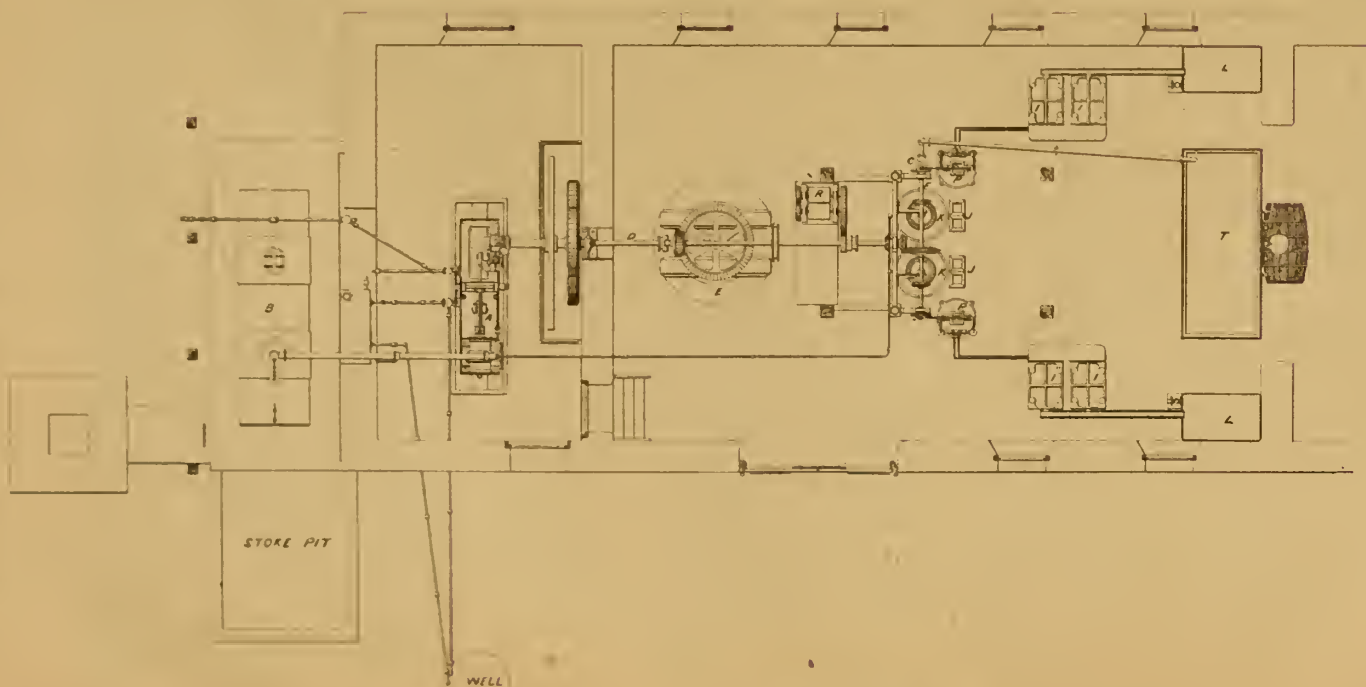
Dated September 24th, 1870.

2561 H. Hewitt—Pens and Penholders
2562 G. T. Bousfield—Type
2563 G. Price and G. A. Price—Washers
2564 J. Apsey—Chaff-cutting

Dated September 26th, 1870.

2565 H. and J. Lomax—Sewing-machines
2566 D. Pirie and A. Croom—Paper-cuttings
2567 T. M. Nall and S. Newton—Sunshades
2568 H. Highton—Meat, fish, &c.
2569 D. Johnson—Cleaning grain
2570 H. J. Jones—Drain pipes
2571 L. W. Weeks—Steam boilers





SEED OIL

MILL

BY

MESSRS. G. BUCHANAN & Co.

P. Soames, A.K.C. direx.

THE ARTIZAN.

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1st NOVEMBER, 1870.

SEED OIL MILL.

By Messrs. G. Buchanan & Co., London.

(Illustrated by Plate 366.)

Amongst the numerous manufactures which have been established in tropical or semi-tropical climates, few, if any, have met with greater success than that of producing oil. In nearly all parts of the world where the climate is sufficiently mild to promote rapid vegetation, oil producing plants grow so abundantly, that they are not unfrequently regarded as weeds. In some cases—as for instance, the ground nut *(Arachis hypogæa)*, the castor oil plant *(Ricinus communis)*, the til or gingelli seed *(Sesamum)*, &c.,—they grow so freely as to cause serious annoyance to the cultivators of other crops, who, consequently, regard them as worse than useless, and no doubt, in such cases, they would be injurious. There is, however, an enormous amount of inferior land, which might be utilised for growing many of the various descriptions of plants, bearing seeds or fruits, that could be profitably employed for the manufacture of oil. In fact, there are large tracts of country which have been absolutely taken possession of by these plants, and where the only amount of cultivation —if it may be so called—that would be necessary, would be, to collect the seeds, and leave the plants to take care of themselves. In these cases, it is obvious, that in order to profitably manufacture oil, the two principal points are economy of labour for the collection of the oil producing material, and economy of production in the mill. The first point is not within our province to discuss, moreover, it can of course be easily calculated for any particular district. As regards economy of production, we illustrate in Plate 366, a very simple and compact form of mill, suitable for the manufacture of almost any description of oil from seeds. We may remark, however, that for the manufacture of ground nut oil, a pair of stones is generally substituted for the crushing rollers shown at *I* in Plate 366.

In many places, the old method of grating the seeds, and afterwards boiling and skimming, is still followed, but, the expense incurred for fuel and labour in this process is so great, that but little profit can accrue to the manufacturer. It is, moreover, a very slow process, and the residuum is entirely wasted; whereas, by the employment of the hydraulic press, the oil-cake of many of the seeds might be utilised. The first runnings of the ground nut and of the til seed are nearly as good as olive oil. The oil from the til seed especially, is consumed in enormous quantities for culinary and also for illuminating purposes. The castor oil seeds contain a very large proportion of oil, being about 62 per cent. of the kernel when deprived of its skin. Although, as is well known, it cannot be used for the same purposes as the oils just mentioned, it is a very good machinery oil, and is also frequently used for making soap.

In Plate 366 is illustrated a complete oil mill, by Messrs. Buchanan and Co., London, where the amount of labour required is reduced to a minimum. The process of manufacture is very simple. The sacks of seeds are first raised up by the hoist *H* to the upper floor, and are emptied into the seive *S*. The meshes of this seive are of such a size that any dirt or foreign seeds drop through, while the good seed is passed through to the bin *W*. From this bin they are allowed to pass between the seed rollers *R*, which are placed directly underneath, and are driven from the main shaft *D* by means of multiplying gear. Here the seed is crushed, and in the case of some descriptions of oil-producing berries it might be at once heated, preparatory to being pressed; but generally it is advisable to pass the crushed seed to the edge runners *E*, where it is completely reduced to pulp. It will be seen that from the time the seed is raised by the hoist, the whole of these operations may be performed without any manual labour, the seed passing gradually down, by its own gravity, through the different processes until it is ready for the kettle. The kettles *K* shown in the accompanying design (Plate 366) are heated by steam supplied by the boiler *B*, and are caused to rotate by means of bevil gearing worked from the cross-shaft *F*. The pulp, after being sufficiently heated, is placed in leathered horsehair bags, held in the bag-holders *J*, and, when filled, are packed in the hydraulic presses *I*, worked by the pumps *P*, which are driven by means of cranks on the ends of the cross-shaft. These presses are usually worked up to a pressure of from two to two and a-half tons on the square inch. The oil which is thus squeezed out of the pulp runs into the receiving tanks *L*, which are usually made of sufficient capacity to hold one day's supply. The oil is pumped up from the receivers to the settling tank *T*, in which are fitted draw-off cocks placed at different levels. This is for the purpose of obtaining different qualities of oil, the finer qualities being used for cooking, or, for salads, &c., instead of olive oil; the lower qualities being suitable for burning, &c.

From the above description it will be seen that when once the seeds are collected but little manual labour is required to extract the oil from them; and, as in many places the collection and delivery of the seed may be contracted for at a fixed rate, the total expense of manufacture can be easily estimated.

Although in some countries the requisite amount of seed can be obtained nearly all the year round with equal facility, and thereby give full employment to the mill; in other countries the crop-times are clearly defined. In the latter case full employment may also be frequently obtained by manufacturing oil from several different kinds of seeds, the crop-times of which are at different seasons of the year.

Should, however, it be found that seeds cannot be easily obtained except at certain seasons, it is generally advantageous to combine some other manufacture with that of oil-crushing, in order that full employment may be given, both to the manual and steam power at command.

In some cases this is effected by attaching the engine to a small mill for shelling rice or ginding corn, which can be erected at a comparatively trifling extra expense. If, however, it happens that the times of these crops clash with those of the seeds, a small saw mill might be attached with advantage, which of course could be worked at any season of the year.

ARRANGEMENT OF CLARIFIERS, &c., FOR A SUGAR HOUSE.

(*Continued from page* 218).

The clarification, or, as it is termed, the defication of the cane-juice, is perhaps the most important part in the process of manufacturing sugar. It has been already remarked that besides sugar and water the cane-juice consists of various other substances, such as green feculæ, green wax, gum, gluten, and various salts of lime, potash, soda, &c., and also a peculiar substance the composition of which is unknown. All these substances are more or less injurious, while some of them, such as the organic compounds just mentioned, actively induce fermentation, and it is believed retard crystallisation, the inorganic compounds act chemically and more or less injuriously upon the sugar itself. It is, therefore, of the greatest consequence that all these foreign matters should be eliminated as completely and speedily as possible. To effect this object an almost innumerable variety of processes have been proposed from the dangerous materials, such as corrosive-sublimate, and subacetate of lead, down to the harmless compounds of alumina and calcium. It is not, however, our purpose to describe these various processes, which have been all more or less failures, but simply to illustrate the almost universal practice of defication by lime.

In working with a steam clarifier such as that shown in the accompanying engraving the following process is usually adopted:—As soon as the coil of steam-pipes, shown near the bottom of the clarifier, is covered by the juice, the steam from the exhaust pipe of the mill engines is allowed to circulate through them, and also through the double bottom of the pan, so that by the time the clarifier is full the juice is already hot. When the liquor has attained a temperature of about 140° a small quantity of the finest ground lime, previously made into a milk by being mixed with a little cane-juice, is thrown in, and thoroughly stirred into it. It is then left alone, and the temperature allowed to rise until the thick scum which forms at the top begins to harden and crack, when the steam is at once shut off. This generally takes place at a temperature of about 180° to 200°, but on no account should the temperature be raised to boiling point. The amount of lime necessary to neutralise the acidity of the liquor, and effect the coagulation of the albumen, or, in other words, to properly clarify the liquor, is somewhat variable, and it requires considerable experience to judge correctly. The usual allowance is about one pound of temper lime to every 600 gallons of juice when the canes from which it had been produced were in good condition, and had not been kept too long after having been cut; although perhaps the taste and smell is the best guide. In some cases, especially when the operator is afraid that there is a large amount of acid, the use of litmus paper is advantageous, but care should be taken that the fatal mistake of putting in an overdose of lime be avoided. After allowing the liquor time to settle, which is usually said to be about a quarter of an hour, although we prefer about double that time, and for that purpose would recommend an ample supply of clarifiers, it ought when examined in a glass to have somewhat the appearance of sherry which has not been properly fined. Small feculæ will be observed floating about in it, showing that although apparently clear and bright, the process of defecation is by no means perfect. It is a curious fact that the system of defecation by means of lime has been practised by the Chinese from time immemorial, and although, as we have seen, it is far from perfect, no other process has as yet been discovered which is open to fewer objections.

The accompanying illustration of a steam clarifier will be so readily understood, that but little explanation is necessary. Fig. 1 is a sectional elevation, and Fig. 2 a plan. It will be seen that it consists of a rectangular cast-iron cistern fitted with a double bottom. The space thus formed, is connected with one end of the coil of pipes situated at the lower part of the pan, as shown in Figs. 1 and 2; a small condense water-cock being in any position in the bottom lining of this space, and an air cock as shown in Fig. 2 at one end. The coil of pipes are made of copper, and are clamped together for the convenience of lifting when required. The two ends of the coil are fitted into stuffing boxes, the upper end (Fig. 2) being in connection with the steam pipe, and the other communicating with the space formed by the double bottom of the clarifier. By means of a steam-cock attached to the upper stuffing box, the steam may be admitted into the coil, and thence to the bottom of the clarifier; the amount of steam, and consequently the amount of heat being

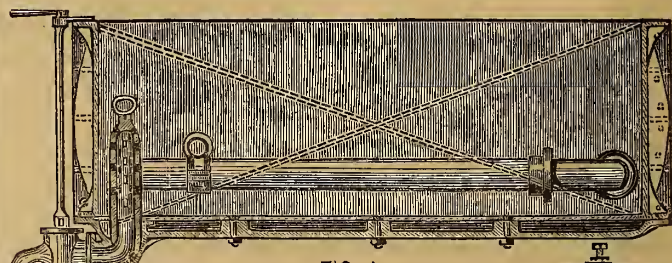


FIG. 1.

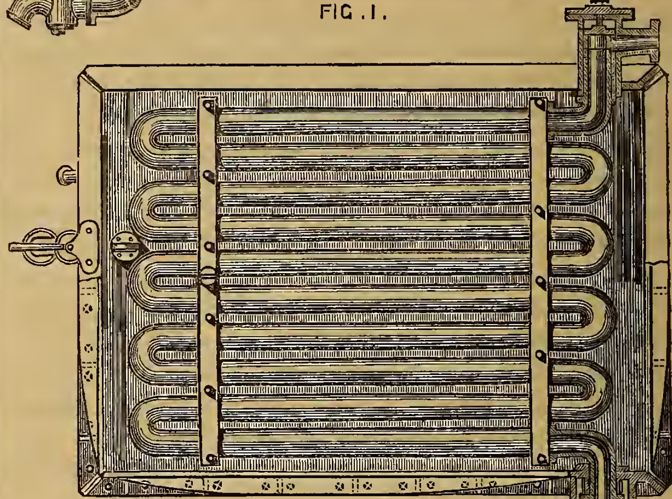


FIG. 2.

regulated with the greatest nicety. The stuffing boxes just alluded to are for the purpose of allowing the coil to be raised up for the purpose of cleaning out the clarifier, an eye bolt being fitted to the clamp shown at the other end of the coil (Fig. 1) which when raised causes the extremities of the pipes to rotate in the stuffing boxes. A plug is placed in the orifice to which the draw-off-cock is fitted, and perforated with holes placed at a suitable distance above the bottom of the clarifier, in order that the sediment formed during the process defecation, may be prevented from being carried off with the clear liquor. In drawing off the juice a small quantity of dirty coloured liquor comes off first, which is usually returned into another clarifier in the process of being filled. The clear liquor is then run into the filters or evaporating pans, as the case may be, and, as soon as the whole has been drawn off,—shown by a change in colour, which can be at once detected by the eye—the cock is shut, the plug is then raised, and upon the cock being again opened, the rest of the contents of the pan is usually run off into the still-house.

(*To be Continued.*)

REPORT ON THE SUEZ CANAL.

By T. Login, C.E., Executive Engineer.

(*Continued from page* 220.)

Up to the time of my leaving Suez no observations had been taken to determine with any great accuracy the velocity of the tides in and out of the canal at Suez, but it had been observed that there is a slight flow of water through the canal northwards from the Red Sea to the Mediterranean; but that it is very slight I can testify, for on one of the occasions when we dropped anchor in the small steamer going up the canal (we never did so coming down) I dropped crumbs of bread into the water to try and discover if there was any current, and though I could perceive the bread sinking two or three feet below the surface, yet I could not perceive any current up or down the canal. That there is a slight current northward I believe, and the question is how to account for it. The tidal wave passes Suez at a considerable velocity, and reaches the Bitter Lake probably before high water at Suez, so there is a regular stream into this lake.

The momentum thus given to the water will keep a stream of water pouring into the lake long after high water at Suez; for the area of the lake being several square miles the rise in it will be little, comparatively speaking. As soon, however, as it does rise, there must be a similar flow northward through the canal into Lake Timsah, which will slightly raise its level; and, again, if this level be thus raised above the main level of the Mediterranean, a similar action will take place here also, and water will flow northward; very slight, indeed, but enough to prevent it being quite stagnant.

Again, with the ebb tide, the rise of the level water in the Bitter Lake being so little, and it being upwards of fifteen miles from the Red Sea, connected by a narrow canal, the few inches rise can have but little effect in causing a flow out of the lake southwards between half ebb and half flood; so that the outflow southwards must be much less than the inflow northwards, for everyone who has observed the time of high and low water, and the time of the turning of the tide, must know that owing to the momentum the current has attained, the water begins to rise or fall some time before the tide turns in mid-channel.

Now, as the rise and fall in the Red Sea is five feet, the rush of the tidal wave up the canal northwards must be much greater than can possibly be attained by a slight rise of probably a few inches, and the extra momentum thus attained by the flood must take a considerable time to be overcome by the outflow back from the Bitter Lake, consequently the direction of the ebb must be shorter and less rapid; so the conclusion I thus arrive at is that the average level of the Bitter Lake now, will probably be found to be somewhat higher than that of the Red Sea, even though there is a loss by evaporation.

It is thus I would venture to explain why there should be a flow northward up the canal from the Red Sea into the Mediterranean, but I hope shortly to be able to forward a note on the experiments now being made, which the officer in charge at Suez kindly promised to furnish me with. However, it has been generally observed that the flood tide at Suez up the canal is considerable in comparison with the ebb. Be it owing to causes now given, or evaporation, or probably both combined, the effect on the canal channel will be to widen or deepen it at the Suez end; and unless the sides be protected it may become in time funnel shaped like the mouths of all tidal rivers; so I think this should be guarded against, and rather deepen than widen the channel, for the transporting power of water decreases as the depth increases, it is believed; and, therefore, if this be true, less silt will be brought up the canal into the Bitter Lake. This, however, appears to be more a question of interest rather than importance, but in the case of the tendency to silting up of the mouth of the harbour of Port Said, it is quite another matter, and should be most carefully considered. I believe, however, that it will not become a pressing question for these next ten years, so that there is plenty of time, and before it arrives there will be, I believe, plenty of funds to meet the difficulty.

Having thus fully gone into the questions connected with the two extremities of the canal, I fear it would occupy too much time to describe the manner in which the breakwater is made of blocks of Beton, though it was fully explained to me, but which has already been described in several works, so I content myself by sending a specimen of the Beton made for the Port Said break water.

Regarding the canal itself there is no necessity to say much, for in an engineering point of view, it is simply a great ditch, hardly exceeding the Ganges Canal in cross sectional area at some parts, and much less than it, as to length. Any one who has seen the deep digging at the Synabas ridge at the 12th mile of the Ganges Canal, and the Purean Kullea one five miles further down, before the slopes were dressed off, can form a pretty correct conception of what the appearance of the Suez Canal is in deep digging, with this difference only, that we had clay where in Egypt they had chiefly sand. In opening the Suez Canal for traffic before the slopes were dressed, I think the Canal authorities showed great sense, for such a work looks much more imposing before than after the slopes are dressed.

As an engineering work the difficulties to be overcome were little in comparison to those on the Ganges Canal, where so many mountain torrents had to be crossed, and a channel had to be dug, and regulated by falls for a running stream, not a still water one; while on the Suez Canal there are neither locks, bridges, or falls, and all these difficulties may have been said to have been overcome when they got fresh water, and the dredges were set to work, for then it was only a question of time and money.

It is not necessary for me to say anything about the dredges, and how they worked, but I will pass them by as the French Engineer did, who had been describing to me the process of making Beton, when he said "that is the steam engine which drove the works, but there is no need wasting time looking at it."

The two difficulties, I may say the enormous difficulties, the Suez Canal authorities had to overcome, were the organization of labour and the want of fresh water. Any one who has had 5,000 or 6,000 workmen to keep in order out in India can but form a slight idea of the difficulties of collecting people of all nations, Europe, Asia, and Africa, and organising them into efficient labourers, but this was effected by the same process which never fails in India, namely, paying one and all for the actual work done.

As to the want of fresh water, I shall simply mention that at one time the chief engineer had, he told me, three thousand camels employed bringing to the works the necessaries of life; so I need say no more as to the difficulties at starting, any one who has ever been exposed to a burning sun, and short of water, can imagine the rest. So I shall pass on to the question of drift sand.

That this has and will cause trouble and inconvenience there can be no doubt, but I look on it more as a "bugbear" than anything else. That sand in large quantities is moved by the wind, and will be blown into the canal, no one will dispute, but when the remains of canals made thousands of years ago are to be found, surely the Suez Canal is not going to disappear all at once by a dust storm; but this also may be overcome, of which more hereafter.

The next difficulty raised is the silt deposit in the canal. It has been already shown that there is no current to speak of in the canal, except at the Suez end, so the mischief is confined to the last 15 miles of the canal, and till I get a report of the observations that are now being taken, I cannot speak with any certainty as to the velocity or scour along this portion, but from what I observed, I do not anticipate much difficulty even in this short distance.

A very important question, which, though it may not be seriously entertained now, will most probably be brought forward ere long—namely, as the level of the sweet water canal at Ismailia is several feet above that of the Timsah Lake, could not more water be taken from the Nile to fill the lake and the canal to a higher level for 10 miles on the south side, and some 7 miles on the north, and have a set of locks at both ends to descend again to the levels of Lake Ballah, the Bitter Lakes?

Ship-masters may say there will be delay in passing through the locks, but this could hardly occupy half an hour, and it has been shown that there are from 2 to 4 hours at least to spare, so time can be of no moment, for under any circumstances it will take two days to pass from Suez to Port Said except in cases of emergency seldom likely to occur. There will practically therefore be no delay by having locks with the centre portion fresh water, but possibly a saving of time, for ships could while at anchor get a supply of fresh water of the Nile, and bringing the ships into a fresh water lake will most certainly kill the marine animals attached to the ships' bottoms, thus, instead of a loss of time, there probably will be a great gain by the ships leaving the canal with comparatively clean bottoms.

This, however, is not the advantage I look forward to, but to the reclamation of the desert by irrigation, which is not a matter of donbt but certainty, for there are proofs existing to show that canals were made near Ismailia by the ancient Egyptians, so we would only be carrying out what was formly done several thousand years ago, and the gardens of Ismailia show that only water is required to make the soil most fertile. With Lake Timsah converted into a fresh water lake, which formerly it most probably was (as "Timsah" signifies crocodile, and these creatures live in fresh or brackish water), there could be no difficulty in rnnning branch canals from above the locks, so that all the ground ronnd the Bitter Lakes on both sides, as well as that of Lake Ballah, conld be reclaimed, and not only would the Egyptians be enrichcd, but the Canal Company need no longer fear sand storms. This can no doubt be still carried out by syphons and pass the fresh water under the salt water canal, but the expense wonld be considerable.

To carry this out all that appears necessary is to widen the present fresh water canal from Ismailia to the Nile, and probably a permanent weir or anicut with regulators would be required to be thrown across the Nile near Cairo, where stone is to be had in any quantity. Though this project may at first sight appear too great, yet when it is contemplated to construct similar works across such rivers as the Ganges and the Sutlej where no stone exists, but all must be made of bricks, the proposal does not appear so problematical as some may at first sight think, and I believe it could be carried out at comparatively little cost.

With a weir and regulators at Cairo, a complete command could be had over the supply, so that the whole irrigation system of Egypt conld be vastly improved, for there wonld be no waiting till the Nile rose, as has been the case, but the water could be held up to the required level at all seasons. The work in fact would be similar to the Godavery anicut in Madras, only on a somewhat smaller scale as to length of work.

These permanent works would have to be constructed by Government, probably by contract, and would to all intents and purposes be a State work, chargeable to the whole community, for all would be benefitted more or less, so unpaid labour had better not be employed on such an undertaking, for skilled labour would be required.

In widening the present fresh water canal, however, the ancient laws of Egypt could be put in force with advantage, as the labourers who perform this work would have the first claim on the land to be recovered from the desert, so they would be remunerated by receiving title deeds to plots of land according to the work performed, thus all would be done without putting the Government or the Suez Canal Company, to any extra outlay, while it would be quite in the spirit of the ancient Egyptian laws, to which I referred in my other report on Egyptian irrigation.

In 1865, before I knew anything about these ancient Egyptian laws, I suggested in my report on the irrigation of the Rechna Doab, that to induce people to come and work on the proposed canal at low rates, a promise of land should be given to the labourers according to the actual work done by them, and I stated my belief that such an inducement would draw crowds of labourers, who would gladly work at comparatively low rates under such a promise. What I have since learnt while passing throngh Egypt confirms me in this opinion, and I think it should be tried on all new canals where large tracts of waste land are to be reclaimed.

Viewing the matter in this light it appears to me that making Lake Timsah fresh water would be adding wealth to the Egyptians, while probably also it would be a saving to the shareholders of the Suez Canal. Widening and deepening the canal, as some think is necessary, must be very expensive in deep cntting, if not a difficult and tedions process where the belt of rock crosses the line, while to build two locks at either end before entering the Ballah and Bitter Lakes is a simple affair; so both in an engineering and also in an economical point of view this snggestion appears worthy of consideration—but be it adopted or not, I for my part have little donbt that the Suez Canal will prove a blessing to the whole world, to India in particular, and will ere long enhance Indian revenues several millions yearly by the enlargement of commerce with the West.

We all know by experience that with canals in India there is a time of infancy as well as manhood, and that they take several years before they become remunerative. Possibly such may be the lot of the Suez Canal, and that for a few years to come the transit dues will hardly cover the working expenses, in which case there will be a great loss to the shareholders, and a greater outcry; but as the canal is now admitted as far as it goes to have been a success, and that it will ultimately prove to be a general benefit to the world, let it not be said that the nations of Europe and Asia allowed the loss to fall on the pioneers who constructed this great work.

That the work has been honestly executed and paid for, I have every reason to believe, for on examining the mode adopting of periodically making sections of the work done and measuring up the whole each time, deducting former progress, shows that it would be next to impossible to nse fraudulent measurements, for not only the contractors, but the workmen were paid by these measurements, so that if at any time too great a progress was given and afterwards this excess was deducted, the workmen who were last employed would not be long in pointing out that thcy had been defrauded, and if this was cnstomary and these complaints were not heeded, the work wonld have soon come to a close. The fact, therefore, that the workmen agreed to be paid by such a system where the men employed could not probably be always the same, proves to me that the utmost care mnst have been taken to have correct measurements, in other words, quantities can without difficulty be snbmitted fraudulently, with measurements the fraud is most liable to detection.

Believing therefore that the expenditure has been honestly accounted for, and bearing in mind the enormous difficulties that have had to be overcome, and the benefits likely to accrue, I think that an international guarantee against loss to the shareholders should be given, India bearing its share of this responsibility; or if need be, that a sum of 25 millions sterling shonld be subscribed, and that the 16¼ millions expended plus the interest on capital from the day of the official opening to the day of settlement, should be paid to the shareholders.

With the balance remaining over, the canal could be pnt in complete working order, and lighthouses built in the Red Sea, while by such an arrangement the transit dues need only be nominal—only sufficient to cover working expenses—thus, the returns to each subscribing power would arise from indirect sources rather than direct taxes on ships passing through the canal.

In advocating these views I do so without having any personal interest in the matter, or knowing any one who has money invested, bnt simply from a feeling of justice and gratitude all must feel to those who have conferred such a great benefit to the civilized world.

PUBLIC WORKS IN INDIA.

The Public Works Department does not seem to attract the rising talent of the engineering profession. If the offer of forty appointments only brought thirteen qualified candidates to the scratch there must be a fault somewhere.

We believe that the Secretary of State lately offered thirty appointments to the profession at large without limitation of age, and without exacting any proof of competence further than the usual certificates; for these temporary appointments there were 360 candidates. But there was one material difference between the terms offered to these gentlemen and the conditions under which young men enter the open competition for the permanent appointments, which, of course, onght to be infinitely more attractive. The latter are not graded at home, whereas each of the gentlemen previously referred to was told the exact position and pay, high or low, which he would receive in India. It is generally snpposed that the sneccssful candidates in the open competition are equally certain, as they are more deserving of a fixed gradation and promotion, bnt there could not be a greater mistake; and it is this inferior, not to say degrading, position of theirs which has stopped the competition. It is true that a young man knows the exact pay which he will draw on landing in the country, which is sufficient for the barest necessities, not for the emergencies of Indian life. But that is a mere nothing; surely a man will wish to have some idea of what means of subsistence will be provided for his family five or ten years hence; and in most services, the civil and medical for instance, he could jndge approximately in how many years he wonld be promoted to a higher grade and pay.

A reference to the so-called gradation list of the Pnblic Works Department will show not only that there is no fixed rule of promotion, bnt rather that there is a system mnch more like degradation, and that the yonng competitors, as years run on, get often lower and lower, further and further away from the prospect of a comfortable maintenance.

Dnring 1868-69 thirty-three officers of the Indian staff corps or of Enropean regiments have been thrust into the department, and been placed over the head of the competitors in the same list, who had been professionally educated, proved their competence by a severe test, and approved value still further by working in India for several years, before some of those, now their seniors, had left their mess-rooms.

Now, we have no interest of the most remote description in this matter, or in the whole profession; further, no member of it has addressed us on the snbject, and we are simply prompted by an honest indignation at the dishonesty of these proceedings. Government knows perfectly well that the unfair promotion of an unprofessional or locally-trained officer is a standing insnlt to every civil engineer who is degraded below him; and this insnlt, instead of being forgotten in the course of years, is ever afterwards present, hnmbling his honest pride, and crippling the resources which in any case would barely provido for a gentleman who desired to lead a Christian's life in India as a family man.

Ensign E——, 58th Foot, is placed over a dozen gentlemen of the service. This means, coupled with similar instances, that the latter will not send their wives home this season, although they want it, and that their pale children will have to stay a couple more hot seasons at least in the plains of India. Is this encouragement to the young competitive service, or is it an elaborate and designed system of *baby farming*, which has resulted in the literal dying ont of all competition, and the announcement that it will be really dead and buried next year? We admit that it is now past cure, bnt we have disclosed the process; the spirit of the service, in fact, has been crushed by insnlt and penury, occasionally quioted by soothing mixtures, it will now be buried in a ditch, and we commend the head of the department as a model baby farmer.—*Indian Daily News.*

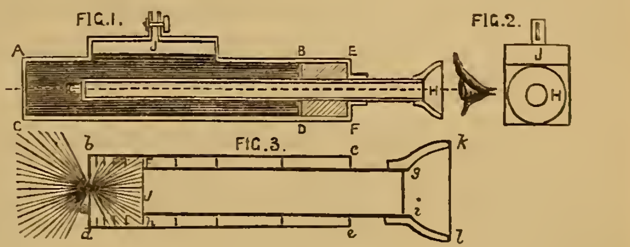
DESCRIPTION OF SOME NEW FORMS OF PHOTOMETER.

By Thomas Stevenson, F.R.S.E., C.E.

In The Artizan of August last, we noticed a form of photometer, said to be invented by M. Nagant, the principle of which was based upon the imperfect transmission of light through a partially opaquo liqnid. We havo since received from Mr. Stevenson a pamphlet, showing that he had anticipated the investigations of M. Nagant, and also has invented another form of photometer, which appears to be of considerable value, from which we abstract the following:—

Having had occasion, during the summer of 1860, to mako some photometric observations, I was led to adopt the following improvements in tho construction of photometers, which it may be useful to record, as I have not anywhere seen an account of similar arrangements. Figs. 1 and 2 represent sections of the instrument. GH in Fig. 1 is the eyepiece, which, in order to shorten or lengthen the column, is thrust inwards or ontwards, whilo J is the eistern for holding the excess of fluid, having a stop-cock at tho top for allowing air to escape. EFDB is a stuffing box filled with soft sponge, by which any leakage wator is readily absorbed, and prevented from coming to the ontside.

I have now to describe a photometer of an entirely different kind from those already explained, and which, so far as I am aware, is new in principle. Tho more immediate object for which it was designed was to snpply a meteorological rather than an optical want, though it also also admits of adaptation to other photometric purposes. I have for some time back remarked that several very heavy westerly gales have been preceeded, at greater or lesser intervals, by unnsually dark, gloomy weather. In one case this diminution of daylight was so great as to produce a sort of noonday-twilight, and was the precursor of a heavy storm. A greater nnmber of observations can alone determine whether the suspicion be well founded that these two atmospheric phenomena are really connected together. The prognostics of storms are of snch great importance, tending as they do to the preservation of life and property, that I consider the subject worthy of being farther and more minutely investigated. The abnormal deficiency of daylight to which I have referred is so great as to admit of being readily detected by any instrument possessing only a moderate degree of sensibility. For snch a purpose as that of measuring the varying amounts of daylight, it seemed necessary that the instrument should be portablo and convenient for travellers. It seemed further obvious, that to employ any absorbing



medium was objectionable, for there is no known fluid which possesses a constant degreo of transparency. Evcu though such a fluid conld bo found, it is still, I believe, an nnsolved difficulty in physical optics to reduce the results to a nnmerical valne; for the snccessive decrements of light produced by passing through eqnal snccessive length of flnid may not bo cqual. Supposing it has been found that one beam of light requires two inches of the medium to extinguish it, whilo another requires only one inch, we may still be unable, from such data, to arrive at accurate qnantitative values. Conld the amount of daylight be ascertained, as is done in experiments on the diverging rays of lamps or candles, by simply measuring the relative distances of the photometers from the radiants, the difficulty would disappear, and we should at once be enabled to arrive at numerical valnes, because the decreasing intensity of a diverging cone of light is in each case inversely proportional to the squares of the given distances from tho radiant.

It occurred to me that this method of trial might bo attained by allowing a minnte portion of daylight to pass through a small hole pierced in a diaphragm, behind which tho light, spreading into the dark chamber in concentric spherical shells, would diverge over nearly 180 deg. The intensity of this diverging light conld then be ascertained by moving a transparent diaphragm near euough the aperture to allow the eye to decipher any charactors that may bo inscribed on it; and in all cases the distances of the diaphragm from tho aperture necessary for prodncing distinct vision would at once represent, in the inverse duplicato ratio, tho intensities of tho rays. By arranging numbers in any order unknown to the observer, the possibility of mistake, arising from his fancying that he has distinct vision when ho has not, might bo prevented. The ability to decipher tho symbols furnishes, iu each case, a certain certain proof that distinct vision has been attained. In Fig. 3, *a* represents the minute holo by which the light is admitted; *b c d e* and *f g h i* represent tho outer and inner tubes, having nnmerous stops iu their inner surfaces to prevent stray rays from being reflected to the eye; *h* is the transparent diaphragm, which may consist either of oiled paper or ground glass, and *k l* is tho shield for the observer's eye.

CAPTAIN SCOTT'S GUN CARRIAGE.

An interesting trial of the 25-ton Fraser gun, on board tho new turret-ship *Hotspur*, was lately mado in the offing, at Plymouth. This armour-plated ram, designed by Mr. Reed, is the first ship of its kind of construction, having, instead of the revolving turret, a fixed turret, with this large gun, mounted on Capt. Scott's patent carriage, worked on a turntablo inside it.

A party of 30 seamen gunners from tho *Cambridge* were first exercised at gun drill by Gunnery Staff Lieut. A. L. Douglas, and the experimental firing then occurred with the following results: First and second rounds, with 50lb. blank cartridge, recoil 9in.; third round, from starboard after port, with 67lb. blank charge recoil 18in.; fourth round from the same port, with 67lb. (full battering charge), and 600-pounder common shell (empty), recoil 3ft. 2in.; fifth round, from the same port, same charge, 7 degrees elevation, recoil 5ft., with compressor slack two cogs; sixth round from starboard bow port, same charge, gun trained as far aft as possible, seven degrees elevation, recoil 4ft. 8½in., compressor as before;

seventh round from same port, same charge and elevation, and gun trained as far ahead as ship's fittings would permit, recoil 4ft. 3¼in., compressor as before; eighth round from port bow ahead, same charge, 4½ degrees elevation, recoil 4ft. 6in., compressor slackened three cogs; ninth round, from same port and bearing with same charge, 4 degrees elevation, recoil 6ft. compressor slackened four cogs. Motion of firing two rounds was then made, first on port beam, second on starboard beam, and the time taken after order to commence was 3min. 23sec. Time of making the complete circle of the turntable (without firing) was 1min. 30sec. The gun is mounted on Captain Scott's high slide and low carriage, which in addition to its ordinary construction, is fitted with a front hook, working in a hook racer (instead of on a pivot), which prevents the gun from lifting; this carriage is adapted for a broadside ship as well as a fixed turret. The runing in of the gnn was accomplished by five men in 40sec. The training is very easy, one man being able to work it. There is a break fitted to prevent the gun moving in rough weather. By means of a double-crank hand winch, worked by six men, the gnn can be carried from port to port (four ports), by the turntable, making the revolution in a minute and a-half. The bow compressors being effectual no breeching ropes were required. The carriage worked the gun throughout the trial most admirably and greatly to the satisfaction of the authoriteis present, but the firing and concussion consequent thereon did some little damage, scorching the upper deck in front of the turret and destroying gratings on the fore hatchways, &c. This damage, however, can easily be prevented in future by plating the deck with iron immediately in front af the turret, and by pillaring it underneath to give it additional strength, and fixing iron scuttles over the combings of the hatchways. The turret admits of training the gun as follows:—From the two foremost ports, angle of training 70 degrees, say from two degrees across the bow, 68 degrees from line of keel towards the beam. The two beam ports angle of training is 69 degrees,—*i.e.*, from 25 degrees before the beam to 44 degrees abaft.

GOVERNMENT COAL TRIALS.

The *Active*, unarmoured screw frigate, 2,322 tons, 600 horse-power, has lately completed at Portsmouth a series of trials under steam over the measured mile in Stokes Bay, and six-hour runs south of the Isle of Wight, with the object of ascertaining the best form of furnace to give the maximum amount of developed power by the engines with the minimum amount of smoke and heat lost through the funnel per ton of coal burnt. As regards the returns obtained from the furnace and coal trials on board the *Lucifer* and *Urgent*, those now concluded on board the *Active* fully confirm their accuracy on every point, and prove the care with which they were conducted. The trials have in reality been carried out with the object of arriving at the results above stated, and without reference to any question of the comparative merits of Welsh and North Country coals for the Royal Navy; but as the trials progressed it was found quite impossible to ignore the question of the comparative qualities of coals in trials where the comparative qualities of furnaces to burn those coals were under consideration. The official report of the trials sent to the Admiralty appear to establish the facts that the new form of furnace introduced during these trials, at their commencement, on board the *Lucifer* and *Urgent* is much superior to the old form of furnace as a power-developer and smoke-consumer per amount of coal burnt. It is, however, important to observe, as affecting simply the peculiar qualities of North Country or Welsh coal, that the new furnace does not seem so well adapted for burning Welsh coal as it does for burning Welsh and North Country together in equal quantities. In the shortened length, and, therefore, reduced fire-bar area, of the new furnace, as compared with the old, the Welsh coal burns sluggishly; but an equal quantity of North Country coal mixed with it makes up a splendid steam-generating fire. Taking another experiment, it was found that by burning on one occasion Welsh coal in the old furnaces, and on another mixed Welsh and North Country in equal quantities in the new furnaces, the difference in the results obtained was thirteen per cent. in power obtained and in fuel burnt to the advantage of the mixed coal and new furnaces.

THE GAS SUPPLY OF THE CITY.

Dr. Letheby, the chief gas examiner appointed by the Board of Trade, has recently presented to the Court of Common Council a report on the results of the daily testings of gas supplied to the City during the past quarter by the City of London, the Chartered, and the Great Central Companies. With respect to the illuminating power, he states that the common gas has ranged from an average of 16·93 standard sperm candles in the case of the Chartered Company at Gray's-inn-road, to 18·34 in that of the Great Central Company at Friendly-place, Mile-end. The average proportions of illuminating power at the several testing places had been as follows:—City of London Company cannel gas 25·87 and common gas 17·37; Chartered Company, at Leadenhall-street, 17·64, and Gray's-inn-lane, 16·93; and Great Central Company, 18·34. The power has thus been at all times above the requirements of the Act of Parliament. As regards impurity, sulphuretted hydrogen had not been present at any time in the gas of any of the companies during the quarter, and the amount of sulphur in any other form had ranged from an average of 13·28 grains per 100 cubic feet of the cannel gas of the City of London, to 27·87 grains in the common gas of the Chartered Company. The maximum, minimum, and average amounts of sulphur were as follows;—City Company, cannel gas, 17·5, 9·6, and 13·28; common gas, 26·4, 15·0, and 21·84; Chartered Company at Leadenhall-street, 27·6, 15·3, and 22·97, and at Gray's-inn-lane, 34·5, 18·1, and 27·87; and the Great Central Company, 31·7, 12·4, and 21·19. The amount of ammonia had not exceeded the prescribed quantity of five grains per 100 cnbic feet, excepting on twelve occasions, from the 12th to the 25th of July last, when the gas of the Chartered Company at Leadenhall-street was overcharged with that impurity, but the excess arose from accidental circumstances over which the company had no control.

BRITISH ASSOCIATION.

(SECTION G).—ON THE CONSTRUCTION OF SEWERS IN RUNNING SAND.

By Messrs. Reade and Goodison, Civil Engineers.

All who have had experience in engineering are aware that the most valnable knowledge is often that acquired while contending with unforseen difficulties. The introduction of the present subject to the notice of the British Association will therefore, we hope, require no apology beyond the simple statement that some of the sewerage works entrusted to us having been executed in difficnlt sandy ground; we are desirons of recording for the use of others some of the experience necessarily obtained. Probably no one who has not watched the process of laying sewers in ground similar to that which distinguishes the land on the Liverpool, Crosby, and Southport Railway, the whole distance from Waterloo to Southport, can form any idea of the difficnlties that have to be encountered. The whole of that district is one mass of sand, resting on a bed of moss and marl, varying from 10ft. to 20ft. deep below the surface; and having no natural drainage—in conseqnence of the elevation of the shore line of sandhills—in wet seasons, in the lower portions or slacks, flushes of water form. The permanent water level in the dryest seasons in these places is only a few feet below the surface, while sink where you will, before you get to the depth necessary for a sewer, you are sure to come to water. Now water in gravel or rock is not difficult to contend against, bnt in fine blowing sand it forms a subsoil of running sand or quicksand of the most lively and insinuating description. Sheet pile or trench as you may it streams in between the sheeting in streams of sand and also forces itself bodily npwards in the bottom of the trench by a species of disguised hydrostatic pressure. To keep open more than a short length of trench the fnll depth during the laying of the pipes is impossible, and consequently the difficulty of laying the invert of the sewer to a true gradient is immensely increased, while the low gradients demanded by the general flatness of the country require for the efficiency of the sewers extreme accuracy. When practical, in order to relieve the ground of water, it is advisable we find, when it can be done without timbering, to open out a long length of cutting abont 5ft. or 6ft. deep beyond where the pipes are actually being laid. In our works, from motives of economy and others reasons, we have mostly used pipe sewers, socketed, glazed, and jointed in cement. Theoretically, such pipes with cement joints should form impervious sewers, but they do not; with the ordinary system of laying we know this to be impossible. The consequence is that where you have several miles of pipes the subsoil water that enters the sewers is enormous. Summer or winter the flow is unceasing, nor is this in itself a disadvantage but rather the contrary, for the tendency of the flow is to keep the sewer sweet aud clean. The Blundellsands main sewer, which, with subsidiary sewers is about two and a-half miles long, in dry frosty weather last winter when gauged showed a discharge of 180 gallons per minute, three-quarters of which at least would be subsoil water, and apparently, except during rain, the flow does not materially differ at various seasons. This, then, as far as the water is concerned, is a distinct advantage, but along with the water, sand streams in and forms a deposit along the whole length of the sewer, which is only removed by frequent flushing. In every case where pipes are laid in running sand, however well and carefully the joints are made, we find this to occur. To get the cement to set before being washed into the sewer is no easy matter. In laying the pipes about twenty yards of timbered trench is opened at one time. A dam of sods, &c., is then formed across it in front of the pipes, and the sand between it and the pipes is dug out until a hole is formed from which the water can be baled out into the trench above, from which it is pumped to the surface. When all is prepared the pipes are lowered down into the trench one by one, the joints bedded being laid on a bed of clay puddle 6in. thick; the joints are then made good with quick setting cement, and the cement is covered all round with a good collar of clay puddle to prevent it being washed into the sewer. With very great care and judgment a good sewer may thus be formed, but not a water-tight one, and we always find that the subsoil is drained nearly to the level of the invert in the very best and most carefully constructed sewers we have yet seen. This in itself is a positive advantage, but the consequent admission of running sand—and it is astonishing how fine an opening it will run through—is an evil which it would be well if possible to guard against. In addition to this, the sinking of the baling out hole while laying the pipes has a tendency to draw the end pipes downwards, and thus interfere with the true gradients of the sewers. In all sewers in ground of this nature we have also to form what is called a sump-hole at the bottom of each manhole, or these would speedily get choked. By the aid of the flushing apparatus, which we shall presently describe, the deposit in the sewers is flushed into these sump-holes, and then cleaned out at intervals. It is difficult to convey to anyone who has not seen it the insinuating nature of this sand, but by attention and frequent flushing we find that well laid pipe sewers in such ground can be kept clean and sweet. Though sewers are possible and effective, laid in the manner just described, it is a matter of much care and attention to get them laid properly, and it is really essential that a clerk of the works should himself see every individual pipe laid; with all this still imperfect joints occur, for as soon as the baling out ceases, as the pipes are practically plugged up with a straw plug, which is drawn through the sewer to keep it clean, the level of the water rises sometimes even above the top of the pipes, and the hydraulic pressure thus created will find out all imperfections, and sometimes prevent the cement setting properly. Again, in putting in the sump-holes the tendency is to draw the nearest pipes out of level, and indeed the most satisfactory way of getting them in is to sheet pile them all round. Having had all these manifold difficulties to encounter we set ourselves to try and devise some method by which greater care in and perfection of laying could be obtained.

The model of the subsoil drain and pipe rest we now have the honour of showing you is partially the result of our experience in laying sewers in sand.

to ensure greater certainty and perfection in the gradients and junctions, and consequently improve the general system of pipe sewerage. That this is of the utmost importance none who practically understand the subject can doubt, for the difference between brick sewers and pipes often means whether sanitary work shall go on, or be stopped. The subsoil drain, it will be seen by an inspection of the engraving, is in internal section a semicircle, and varies in diameter according to the diameter of the superimposed sewers; for 2ft. pipes we purpose using drains 1ft. diameter; for 1ft. 6in., 9in. diameter; and for 1ft., 6in. diameter. The length is the same as the pipes in the sewers, that is either 2ft. or 3ft. as the case may be. The larger pipes we use in 2ft. 6in. lengths. Each pipe is socketted, and the sides being brought up square a shoulder is formed, on which the bricks forming the rest, which also fit the top of the drains and the curvature of the pipes, are laid. The pipes in the sewer above are arranged so that they break joint with the subsoil drains and the ends of each sewer pipe rests on the adjoining subsoil pipes. It will be seen that this arrangement secures ample space under the sewer for making the cement joints good. The operation of laying the subsoil drains is somewhat similar to that previously described as the mode we adopted for laying pipe sewers before employing this invention, the only difference being that the joints are made in clay alone, and from the small size of the pipes they can be handled and laid much more readily; slight imperfections in the gradients also will not be of the same consequence as in the sewers. When a sufficient length is opened out we commence laying the sewer pipes upon the brick saddles or rests which have previously been accurately laid to the proper levels from sight rails in the usual manner. As this can be done without hurry or confusion a more perfect sewer is the result. The subsoil drains are continued through some of the manholes, as shown in the engraving, Fig. 2, and are united to the main sewer at intervals discharging their contents into sumpholes which retain the sand that may be brought down by the water and which then can be readily cleaned out when necessary. In each of the intermediate manholes where the subsoil drains are carried through they will be fitted with a disc plug on the top for the purpose of flushing. When the flushing valves, to be hereafter described, are down the removal of any of these disc plugs will allow of any portion of the drain being flushed with a good head of water. It will thus be seen that while we retain all the advantage of subsoil water we avoid the evils of running sand, which, if not attended to, accumulates in the bottom of a sewer, cakes with the sewage matter, and obstructs the flow. Perhaps some

FIG. 1.

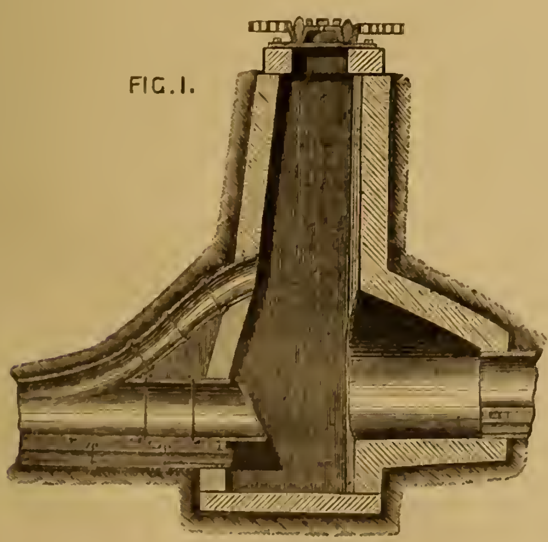


FIG. 2.

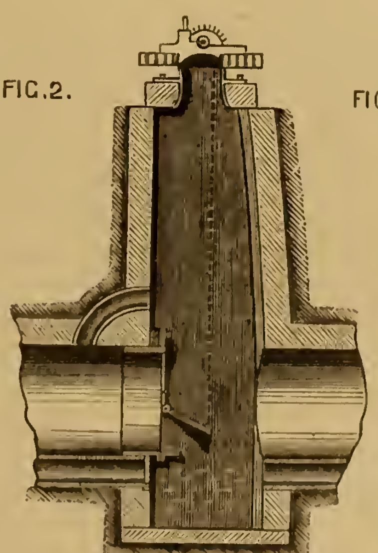


FIG. 3.

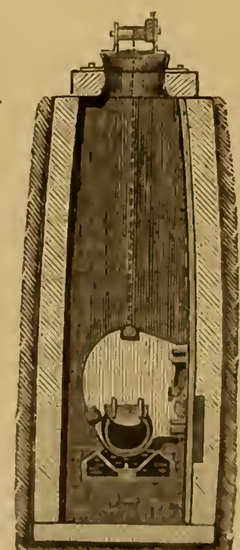


Fig. 1.—Showing section through manhole, with flushing valve and subsoil drain.

Fig. 2.—Showing section of sluice-gate to brick sewer.

Fig. 3.—Showing section of manhole, with winch for raising sluice-gate and flushing-valve.

At our suggestion Messrs. Brooke and Son, of Huddersfield, the fireclay pipe manufacturers, have worked out the invention in a practical form, and we are now commencing to use it in the sewerage works at Birkdale. The primary object of attainment is this—to get a dry subsoil wherein to lay the pipes, that the cement joints may have time to set and become water-tight, and by securing more time for the laying of the pipes, laying a greater length at a time, and the prevention of disturbance or drawing of the pipes while preparing the next excavations,

may think that it would be better to keep the flow of subsoil water entirely separate from the sewage by continuing the drains through or round all of the manholes with provision for admitting the subsoil water into the sewers wherever required for flushing. Special cases undoubtedly require special treatment, and in the case of wet gravelly ground it may sometimes be an advantage when using the subsoil drains to carry out a separate system, but in running sand the case is different, for without a certain number of sump-holes the drains would infallibly get choked, and to fit the subsoil drains with separate manholes and sump-holes would unnecessarily complicate the sewerage works, besides introducing other evils. As a rule, we are in favour of introducing subsoil water into sewers, as a constant flow tends to sanitary efficiency, but where the sewage is to be used for irrigation it may in some cases render it difficult to dispose of the whole of the sewage, especially where pumping has to be resorted to. There are, however, to our mind so many objections to a separate system that we should not adopt one except for very special reasons. None can lay down rules and formulæ for inflexible guidance in engineering matters; all that can be done is to state principles, and the intelligence of the engineer must be his guide in their application. Though primarily the object sought in the invention of the subsoil drain and pipe rest was the more perfect construction of the sewer proper, it possesses the additional merit of reducing the permanent level of the subsoil water to a lower level than does the ordinary sewer, and is a distinct provision for that object instead of an accidental accompaniment of sewerage works.

Brick sewers it is common to construct with invert blocks, when the subsoil is wet, and they make a very true foundation to build the sewer upon. In running sand we find it very much better to construct the inverts with flanges, and to bed them in clay as a precautionary measure for keeping the sand out of the sewer. After the sewer is completed it is unnecessary to keep the invert drain open, as the brick sewer being porous admits the subsoil water and effectually drains the ground. During the construction of the sewer the invert blocks act as subsoil drains and very much facilitate the work. The experiments we have already made with the subsoil drains have thoroughly satisfied us as to their efficiency. We find that when they are laid the sewer can be constructed with extreme facility with perfect joints, and that the effect of the sewer pipes breaking joint with the sub-drains is not only to strengthen the sewer at the joints and prevent drawing, but to ensure perfection in the gradients. The subsoil drains are in fact a foundation for the pipes of the sewer, and the sewer itself can be as readily constructed upon them as if the ground were perfectly dry. Those who have had experience in running sand will see this is no small advantage independently of the draining of the subsoil which will necessarily occur. We have begun to use the subsoil drains, or "blocks," as the workmen already call them, in the sewerage works we are carrying out at Birkdale, and when by their aid we get the 10,000 yards of intended pipe sewers completed, we shall be in a position to state the results, and to give further information to any engineers who may ask for it.

For all sewers, flushing is of the utmost importance, yet how seldom is any provision made for it except by the introduction of a water company's hose which combines the minimum of effect with the maximum expenditure of water. In all our works we introduce flushing valves, but for sewers in sandy districts they should be used at more frequent intervals, for unless we have abundance of scouring force we are never safe as to the permanence of the sewer. Frequent flushing is of the utmost importance; it is of no use making elaborate provisions that cannot be used when most wanted, or letting apparatus rust for want of efficiency in the executive. Local boards too often think they have done everythink when a sewerage system has been carried out; that it should be constantly attended to is of almost equal importance. No apparatus can dispense with intelligent supervision but we cannot speak too strongly on this point, for, though it is a truism, local authorities act as if everything were self-acting, and only examine a sewer when it is time to pull it up. Unfortunately engineers are partly responsible for this state of things, for their works formerly were, from the absence of provision for flushing, apparently constructed on the same supposition. Flushing gates for large sewers are frequently used, but we are not aware of valves being used by other than ourselves for flushing pipes with their own waters. That all sewers should be flushed with their own waters should be an axiom of engineering, for otherwise in drought when water is scarce, and the deleterious decomposing matters which invariably accumulate in the best constructed tributary sewers most require removing, they stand a good chance of being left to breed fevers and other diseases. By having the valve, consisting of a cylindrical barrel, of the diameter of the pipe it is connected with, built into the manhole, and filled with a flap valve hung to a diagonal face with a brass pin in the hinge, the water accumulates up the sewer until it rises to the safety overflow which should be below the level of any adjoining cellars. When this occurs, sufficient hydraulic power is accumulated to sweep all deposits out of the sewer below to the next valve. It must be understood that the sewer above the valve for a certain distance also shares in the cleansing operation; but the force is greatest near the valve, and it decreases until it reaches a distance sufficient for the whole of the water to get into "tram," when the scouring force is equalised though much diminished. We have used these valves in our works for the last five years, and find them invaluable. They in fact render that possible which would otherwise be impossible. We use them up to 2ft. diameter, but for the larger sizes a small portable crab winch, capable of lifting one ton, and which fits on the manhole cover and to the barrel of which the chain of the valve is temporally attached, is employed to lift them. For brick sewers and sewers of a larger diameter, the flushing gate manufactured by Mr. Samuel Harrison, of Soho Foundry, Liverpool, is used. When not in use it lies back against the side of the manhole and is held in its place by a catch. When closed and screwed up by the handscrews, the water accumulates behind and keeps it tight against its face until reaching the overflow. On to this gate is fixed a circular valve near the invert of the sewer, precisely similar to that described for the pipes, and when it is required to flush the sewer it is suddenly lifted, a rush of water takes place along the invert and sweeps all before it. When all has escaped the gate can be thrown back readily as it is relieved from all pressure. The flow of water being directed to the invert is more effectual than it would be were the gate itself opened, and the flushing force being applied through a smaller orifice lasts longer and is more sustained. The great advantage, however, is that a very large sewer can thus be flushed without any of the mechanical aids necessary for opening a large flushing gate against pressure, and consequently the cost of the gate is not half of that of the ordinary sluice. At the termination of all the sewers we provide a flushing-box and pipe for filling the upper part of the sewer above the first valve, as the natural flow is there, of course, only small. The gullies we use are easily cleaned of sand, and have the advantage of remaining trapped during great drought, as 5in of water must evaporate before the untrapping takes place.

The form of ventilator though applicable to all situations, is especially so for districts where either much loose sand is blown about, or where there is a heavy traffic and consequently muddy roads. The ordinary form, consisting of a brick chamber and separate ventilating grid, under such circumstances soon gets choked with mud or sand, and the consequent damp also destroys the efficiency of the charcoal. In all sanitary works, as we before said, we must have efficient superintendence, and the best method of making that superintendence efficient is to make the work easy and light. The ventilator consists of a combined manhole and ventilating cover. The air grid is in the manhole cover itself, the frame which it fits into being lengthened into an air shaft which is perforated at the side, and the bottom is sealed with the movable mud basket, to prevent any passage of air from inside to outside except through the deodorising charcoal basket. During a heavy fall of rain, or should the cover accidentally be fixed lower than the road and surface water enter, the water may overflow the mud basket. To avoid damping the charcoal, this is provided for by the overflow pipe, which is carried down into the water of the sump-hole which traps it and prevents it becoming a channel of communication between the internal gases and the external air. A small brick chamber or flue is built at the side covered with a cast iron plate to receive the paving. The mouth of this in the manhole is fitted with an iron frame to receive the charcoal basket and the upper part communicating with the perforations in the side of the shaft of manhole cover, and thence with the external air. It is evident from this arrangement that the mud basket can be readily lifted out by its handles and emptied of its contents, and also that no inspection of the sewer can take place without this preliminary operation being guaranteed. We have now described pretty fully our arrangements for sewering wet, sandy ground. Many of these inventions we use also in other places, but the original suggestions for them have arisen from our contentions with sand. In other subsoils, with quick gradients, we only use sump-holes in those manholes where the valves are fixed, carrying the sewer through the intermediate manholes by open culverts constructed in brick, of the form of the sewer, and, in fact, forming the bottom of the manhole, with a shoulder on each side. Undoubtedly the most efficient system of sewerage is that which sweeps all matter away at once at the outlet, and sump-holes should only be used to prevent the possible choking of the sewers. The conditions of perfect sewerage may be summed up thus:—true gradients, as quick as can be obtained, but increasing gradually from the outlet to the branch sewers; perfect construction; requisite depth below the surface; provision for draining the subsoil water to the level of the sewers; adequate flow of water in the sewers; abundance of flushing power; constant flushing; and sufficient ventilation; and real active supervision in the executive. But above and beyond that, the abolition of cesspools, middens, and stagnant pools, together with a perfect house drainage are essential. Often when sewerage works are completed the whole of their utility in a sanitary point of view is vitiated by criminal neglect of the house drainage. It is not merely sufficient to connect existing drains or the overflows of cesspools with the sewers; they should be thoroughly examined, abolished, and the drainage reconstructed where necessary. We have no doubt that defective house drainage is in most cases responsible for local outbreaks of fever and other diseases, rather than the main sewers. We have not treated of the ultimate disposal of sewage, as that is not within the scope of this paper, but may say that we firmly believe irrigation to be the only absolute remedy, and that in time, works for effecting it will be considered an integral portion of any sewerage system. That time has not yet arrived, but we are rapidly approaching it, and we wish the movement "God-speed." To consider sewerage complete when the sewage is only turned into a river, or on to a shore, is barbarity unworthy of the age, and it is the duty of Government, and also we hope its intention, to absolutely prohibit the fouling of the watercourses and shores, and so force the question on to its only logical conclusion.

STREET WATERING.—(CHEMICAL SECTION.)

ON THE PURIFICATION OF PUBLIC THOROUGHFARES BY THE APPLICATION OF DELIQUESCENT CHLORIDES.

By W. J. COOPER.

At Norwich, in 1868, I had the honour of introducing to the notice of the British Association the subject of the application of deliquescent chlorides for street-watering purposes. At that time an experiment had been tried in Baker-street, Portman-square, throughout an exceptionally hot season with successful results, the surface of the macadam road being purified, hardened, and concreted, and the obnoxious dust prevented from rising. In Liverpool, in 1869, Lord-street, Church-street, and Bold-street, were watered with the chlorides during the month of July, and the report of the result was very favourable, and further experiments have been made this year. In many other towns the salts have been tried this season according to the nature of the roadway, and nearly all kinds of pavement have been experimented on.

It is difficult to prove satisfactorily the economy resulting from the use of the chlorides over a limited area. And the Westminster Board of Works, after observing the effect produced at Whitehall and Knightsbridge, resolved to extend the experiment throughout the entire district under their control, comprising an area of 250,000, square yards of roadway. As soon as the area was extended the saving in labour and water was at once made evident. By using one ton and a half of salts per day, costing £3 15s., the labour of ten horses, carts, and men can be dispensed with, costing £4 10s., or 9s. per horse, cart, and man. The quantity of water they would put down is consequently saved, namely, 350 loads of 250 gallons each, or 87,500 gallons, which, at 10d. per 1,000 gallons (the London price for water), would amount to £3 12s. 11d. per day, in addition to the saving in labour of 15s. per day, showing a clear gain of £4 7s. 11d; per day after paying for the salts.

The importance in a sanitary point of view of the use of the chlorides has been clearly established. The chloride of calcium decomposes the carbonate of ammonia of the horse droppings, the result being the formation of carbonate of lime and chloride of ammonium, these salts, together with the chloride of sodium and the carbonate of lime contained in roads, causing the concreting effect so desirable for the prevention of dust. An effective method of remedying the evils arising from organic matter deposited in the public thoroughfares is becoming daily a subject of consideration with sanitary authorities, as much sickness is believed to arise from malaria emanating from this source.

Carbolic acid is used in many towns as a disinfectant, and other powerful and poisonous antiseptics have been used lately in watering the streets. The disgusting odour and dangerous nature of some of these deodorising agents are strong evidence that they would not be used at all if the necessity for some determined action to prevent the spread of contagion and disease was not fully recognised. To completely effect the object of purifying streets and public places an antiseptic is required which may be used freely and without fear. It should be as powerful a disinfectant as carbolic acid, but free from the odour and poisonous nature of that article. The deliquescent chloride of aluminium, recently introduced to public notice by Professor Gamgee, seems to meet all the requirements needed in the antiseptic of the future. It is non-poisonous and free from any odour; it prevents decomposition and arrests it when commenced. It absorbs noxious gases resulting from putrefaction, and destroys parasites and germs; it is also not to be surpassed as a precipitant and deodoriser of sewage, and added to which advantages it is only one-third the cost of carbolic acid.

I propose to add a sufficient percentage of this chloride to the salts used for street watering, and thereby afford a means of thoroughly and effectively purifying public thoroughfares without additional cost to the ratepayers, the value of the water and labour saved being more than sufficient to pay for the use of the chlorides.

NAVAL ARCHITECTURE.

STREAM LINES AND WAVES IN CONNECTION WITH NAVAL ARCHITECTURE.

By W. J. MACQUORN RANKINE, C.E., LL.D., F.R.SS.L. and E.

The lecturer stated that his object was to give a brief summary of the results of some applications of the mathematical theory of hydrodynamics to questions regarding the designing of the forms of ships, and the mutual actions between a ship and the water in which she floats. The art of designing the figures of ships had been gradually developed by processes resembling those called "natural selection" and the "struggle for existence," in the course of thousands of years; and had arrived in skilful hands at a perfection which left little more to be desired, when the object was to design a ship that should answer purposes and fulfil conditions which had previously been accomplished and fulfilled in the course of practical experience. But cases now frequently arose in which new conditions were to be fulfilled, and purposes were to be accomplished beyond the limits of the performance of previous vessels; and in such cases the process of gradual development by practical trials made without the help of science was too slow and too costly, and it became necessary to acquire and to apply scientific knowledge of the laws that regulate the actions of the vessel on the water and of the water on the vessel. Amongst the questions thus arising were the following:—What ought to be the form of the immersed surface or skin of a ship in order that the particles of water may glide smoothly over it? And the form of such a surface being given, how will it affect the motions of particles in its neighbourhood, and what mutual forces will be exerted between the particles of water and that surface? Practical experience, unaided by science, answers the first question by saying that the surface ought to belong to a class called "fair surfaces"—(that is surfaces free from sudden changes of direction and curvature), of which various forms have in the course of ages been ascertained by trial, and are known to skilful shipbuilders. The answer is satisfactory, so far as it goes; but in order to solve problems involving the mutual actions of the ship and the water, something more is wanted, and it becomes necessary to be able to construct fair surfaces by geometrical rules based on the laws of the motion of fluids, and to express their forms by algebraic equations. There were many very early attempts to do this, but not being based on the laws of hydrodynamics they resulted merely in the finding of empirical rules for reproducing, when required, forms that had previously been found to answer in practice, and did not lead to any knowledge of the motions of the particles of water or of the forces exerted by and upon them; and they had little or no advantage over the old process of modelling by the eye and hand, and of "fairing" the lines by the help of an elastic rod called a "batten." As regards this process, indeed, mathematical methods about to be referred to, are to be regarded, not as a substitute for it in designing the form of a ship, but as a means of arriving at a knowledge of the mutual actions between her and the water, which the old process is incapable of affording. The earliest method of constructing the figures of ships by mathematical rules based on hydrodynamical principles, was that proposed by Mr. Scott Russell about twenty-five years ago, and since extensively practised. It consisted in adopting for the longitudinal lines of a ship, curves imitated from the outlines of waves in water. The motions which surfaces formed upon this model impressed on the water were known to a certain degree of approximation. Those "wave lines," however, although they were fair curves in the sense already mentioned, were by no means the only fair curves, but were only one class out of innumerable classes of curves having the property of gliding smoothly through the water; and it was well known in practice that vessels had proved successful whose lines differed very widely from wave-lines. It was, therefore, desirable that methods should be devised of constructing by mathematical rules, based on the laws of the motion of fluids, a great variety of curves possessing the requisite property of fairness, and not limited to the wave-line shape. Such had been the object of a series of researches that had been communicated to the Royal Society at different dates since 1862. They related to the construction of what it has been proposed to call stream-lines. A stream-line is the track or path traced by a particle of water moving in a smoothly and steadily flowing current. If, when a ship is gliding ahead through the water with a certain speed, we imagine the ship to be stationary, and the water to be flowing astern past the ship in a smooth and steady current with an equal average speed, the motion of the ship and of the particles of water relatively to each other are not altered by that supposition; and it becomes evident that if the form of surface of the skin of the ship has the property of fairness, all the tracks of the particles of water as they glide over that surface are stream-lines, and the surface itself is one containing an indefinite number of stream-lines; or, as it has been called, a stream-line surface. It is also to be observed that when we have deduced from the laws of the motion of fluids, the relations which exist between the forms of the stream-lines in different parts of a current, and between those forms and the velocities of the particles as they glide along different parts of those lines, we know the relation between the form and speed of a ship whose surface coincides with a certain set of those stream-lines, and the motions of the particles of water in various positions in the neighbourhood of that ship. The lecturer then proceeded to explain and to illustrate by diagrams the methods of constructing stream-lines. These methods were based upon the application to stream-lines in a current of fluid of a mathematical process, which had previously been applied by Mr. Clerk Maxwell to lines of electric and magnetic force. A current of fluid is represented on paper by drawing a set of stream-lines, so distributed that between each pair of them there lies an elementary stream of a given constant volume of flow. Thus while the direction of flow is indicated in many given parts of the current by the direction of the stream-lines, the velocity of the flow is indicated by their comparative closeness and wideness apart, being evidently greatest where those lines lie closest together, and least where they are most widely spread. If upon the same sheet of paper, we draw two different sets of stream-lines, these will represent the currents produced in one and the same mass of fluid by two different sets of forces.

The two sets of lines represent a network; and if, through the angles of the meshes of that network we draw a third set of stream-lines, it can be proved from the principle of the composition of motion that this third set of lines will represent the current produced in the same mass of fluid by the combination of the forces which, acting separately, would produce the currents represented by the first two sets of stream-lines respectively. The third set may be called the resultant stream-lines, and the first two the component stream-lines. Suppose, now, that a third set of component stream-lines are drawn, representing the current produced by a third set of forces; this will form a network with the previously drawn resultant stream-lines; and a set of lines drawn through the angles of the meshes of this new network will represent the resultant current produced by the combination of the three sets of forces; and so on to combinations of any degree of complexity that may be required. In order to draw a system of stream-lines suited for the longitudinal lines of a ship, three sets at least of component stream-lines must be combined. One of these is a set of parallel straight lines, representing an uniform current running astern with a speed equal to the actual speed of the vessel. A second set consists of straight lines radiating from a point called a focus, in the fore part of the vessel, and they represent the diverging motion that is produced by the ship displacing the water near her bows. The third set of component stream-lines consists of straight lines converging towards a second focus in the after part of the vessel; and they represent the motion of the water closing in astern of the ship. The resultant stream-lines thus produced present a great variety of forms—all resembling those of actual ships, having all possible proportions of length to breadth, and all degrees of bluffness and fineness at the ends, ranging from the absolute bluffness of a sort of oval, to a bow and stern of any degree of sharpness that may be required. It has been proposed to call stream lines of this sort *Oögenous Neoïds*: that is, shiplike-lines generated from an oval; because any given set of them can be generated by the flow of a current of water past an oval solid of suitable dimensions. The properties of these curves were investigated in 1862. They have, however, this defect, that the absolutely bluff ovals are the only curves of the kind that are of finite extent; all the finer curves extend indefinitely in both directions ahead and astern; and in order to imitate the longitudinal lines of a finer ended vessel, a part only of some indefinitely extended curve must be taken. In 1870 an improvement in the construction of such curves was made, by which that defect was overcome; it consisted in the introduction of one or more additional pairs of foci, involving the combination of at least five sets of component stream-lines. By this device it is possible to imitate the longitudinal lines of actual vessels by means of completely closed curves, without using portions of indefinitely extended curves; and thus the knowledge of the motion of the particles of water, as shown by the stream-lines that lie outside the closed lines representing the form of the vessel, becomes more definite and accurate. The lecturer mentioned that the idea of employing four foci and upwards had been suggested to him by the experiments of Mr. Fronde on the resistance of boats modelled so as to resemble the form of a swimming bird, for which purpose stream-lines with four foci are specially adapted. It has been proposed to call such lines, *Cycenogenous Neoïds* that is, shiplike curves of shapes like that of a swan. In such curves, when adapted to fine-ended ships, the outer foci—that is, the foremost and the aftermost, are situated in or near the stem and sternpost of the vessel, which are represented in plan by small horseshoe-like curves, as if they were rounded off at the corners, instead of being square, as in ordinary practice. The inner foci are situated respectively in the fore and after body. When the foci of the longitudinal lines of a vessel have been determined, the proportion borne by the aggregate energy of the motion impressed on the particles of the water to that of the motion of the vessel herself, can be approximately determined; and it is found to range, in different cases, from one-half to the whole energy of the ship. A convenient empirical rule for the approximate displacement of a ship with a true stream-line surface has been incidentally obtained in the course of these investigations: it is as follows: find the positions of the two cross-sections whose areas are each equal to one-third of the midship section; multiply five-sixths of the longitudinal distance between those cross-sections by the midship section; the product will not differ by more than about two per cent. of its amount from the actual displacement, if the ship is bounded by a true stream-line surface. This has been found by trial to hold for various forms and proportion, ranging from a sphere to a very sharp wave-line.

The lecturer next proceeded to explain the bearing of some of the mechanical properties of waves upon the designing of vessels, especially when these properties are taken in combination with those of stream-lines. It had long been known that ships in moving through the water were accompanied by trains of waves, whose dimensions and position depended on the speed of the vessel; but the first discovery of precise and definite laws respecting such waves was due to Mr. Scott Russell, who published it about twenty-five years ago. The lecturer now described, in a general way, the motions of the particles of water, in a series of waves, and illustrated them by means of a machine contrived for that purpose. He showed how, while the shape of the wave advances, each individual particle of water describes an orbit of limited extent in a vertical plane. The periodic time of a wave, its length, the depth to which a disturbance bearing a given ratio to the disturbance at the surface of the water extends, and the speed of advance of the wave, are all related to each other by laws which the lecturer explained. He then stated that Mr. Scott Russell had shown that when the vessel moved no faster than the natural speed of advance of the waves that she raised, these waves were of moderate height, and added little or nothing to her resistance; but when that limit of speed was exceeded, the waves, and the resistance caused by them, increased rapidly in magnitude with increase of speed. His own (Professor Rankine's) opinion regarding these phenomena was that when the speed of the vessel was less than, or equal to the natural speed of the waves raised by her, the resistance of the vessel consisted wholly, or almost wholly of that arising from the friction of the water gliding over her skin; and he considered that this opinion was confirmed by the results of practical experience of the performance of vessels. The wave-motion, being impressed once for all on the water during the starting of the vessel, was propagated onward like the swell of the ocean, from one mass of water to another, requiring little or no expenditure of motive power to keep it up. But, when the ship was driven at a speed exceeding the natural speed of the waves that she raised, those waves, in order to accompany the ship, were compelled to spread obliquely outwards instead of travelling directly ahead; and it became necessary for the vessel, at the expence of her motive power, to keep continually originating wave motion afresh in previously undisturbed masses of water; and hence the waste of power found by experience to occur when a ship was driven at a speed beyond the limit suited to her length. This divergence, or spreading sideways of the train of waves, had a modifying effect on the stream lines, representing the motions of the particles of water. It caused them, in the first place, to assume a serpentine form, and then, instead of closing in behind the ship to the same distances from her course at which they had been situated when ahead of her, they remained permanently spread outwards. In other words the particles of water did not return to their original distance from the longitudinal midship plane of the vessel, but were shifted laterally and left there, much as the sods of earth are permanently shifted sideways by the plough. The place of the water which thus fails to close in completely astern of the vessel, is supplied by water which rises up below, and forms a mass of eddies rolling in the wake of the ship. This was illustrated by a diagram. Lastly, the lecturer explained the principles according to which the steadiness of a ship at sea is effected by waves; and the difference between the properties of steadiness and stiffness. The mathematical theory of the steadiness of ships has been known and applied with useful results for nearly a century; but in the course of the last few years it had received some important additions, due especially to the researches of Mr. Froude on the manner in which the motions of the waves effect the rolling of the vessel. A stiff ship is one that tends strongly to keep and recover her position of uprightness to the surface of the water. A steady ship is one that tends to keep a position of absolute uprightness. In smooth water these properties are the same; a stiff ship is also a steady ship in smooth water. Amongst waves, on the other hand, the properties of stiffness and steadiness are often opposed to each other. A stiff ship tends, as she rolls, to follow the motions of the waves as they roll; she is a dry ship; but she may be what is called uneasy through excessive rolling along with the waves. The property of stiffness is possessed in the highest degree by a raft, and by a ship, which like a raft, is very broad and shallow, and whose natural period of rolling in smooth water is very short compared with the periodic time of the waves. In order that a ship may be steady amongst waves, her natural period of rolling should be considerably longer than that of the waves, and in order that this property may be obtained without making the vessel crank, the masses on board of her should be spread out sideways as far as practicable from the centre of gravity; this is called "winging out the weights." A vessel whose natural period of rolling in smooth water is only a little shorter or a little longer than that of the waves has neither the advantages of stiffness nor those of steadiness, for she rolls to an angle greater than that of the slope of the waves; and her condition is specially unsafe if her natural period of rolling is a little greater than that of the waves; for then she tends to heel over towards the nearest wave crest, to the danger of its breaking inboard. This is called rolling "against the waves." The most dangerous condition is that of a vessel whose period of rolling in smooth water is equal to that of the waves that she encounters; for then every successive wave makes her roll through a greater and greater angle, and under these circumstances no ship can be safe, how great soever her stability. All these principles have been known for some years, through Mr. Froude's researches. The lecturer exhibited a machine which he had contrived for illustrating them, in which the dynamical conditions of vessels of different degrees of stiffness and steadiness were approximately imitated by means of a peculiarly constructed pendulum, hanging from a pin whose motions imitated those of a particle of water disturbed by waves.

LIGHTNING AND TELEGRAPH WIRES.

By S. Alfred Varley, Assoc. Inst. C.E.

In the early days of practical electric telegrapy, which may be said to date from the incorporation of the Electric Telegraph Company in 1846, lightning protectors to protect the coil wires were adopted in telegraph offices. The general type of the protectors employed may be described as consisting of insulated metallic conductors terminating in points in close proximity to a conductor in metallic connection with the earth.

At a subsequent date the use of lightning protectors was almost entirely abandoned. Among the causes which may be mentioned as contributing to their disuse were: 1. From their construction they involved a greater complication in the connections. 2. They occasionally caused interruptions to the telegraph circuits in consequence of the insulated pointed conductors coming in contact with the earth conductor. 3. In practice they were found not to prevent the fusion of the coils, or only exceptionally; for although in the event of lightning striking the wires, the lightning leaped across the space of air separating the pointed conductors, an electrical discharge also passed through the coils, and frequently fused them.

In 1848, Mr. C. F. Varley, taking advantage of the lesser resistance which a partial vacuum opposes to the passage of electricity, constructed lightning protectors, in which the insulated conductors and the earth conductor were enclosed in an exhausted chamber. In the earlier construction of these vacuum protectors the exhausted chamber was hermetically sealed by means of a resinous cement. In practice, however, it was found to be very difficult to maintain the partial vacuum in a chamber sealed in this way; and in 1861, Mr. C. F. Varley abandoned this mode of construction, and adopted lightning protectors in which platina wires fitted into a partially exhausted glass bulb were placed upon a lightning protector of the original type, consisting of insulated pointed conductors in close proximity to an earth conductor. The practical use of these protectors has been almost entirely limited to the protection of the shore ends of submarine cables; the chief objection to them is that the platina wires are frequently fused, and the efficiency of the protector destroyed by the first flash of lightning striking the wires. When lightning storms occur in the neighbourhood of telegraph wires, although the wires may not be actually struck, powerful currents are induced in the wires. These currents may be sufficiently strong in some cases to fuse the coils, but they more frequently simply demagnetise, and as often reverse the magnetism of the magnetic needles which are situated in the coils of needle telegraph instruments; and in a telegraph office during a storm, which may be a long way from the office, it not infrequently happens that the magnetic needles of all the needle telegraphs passing through the district of the storm are again and again demagnetised, and communication on these circuits interrupted for a time.

The annual amount of damage caused by lightning to telegraph instruments is considerable, and varies in different years, but the interruption which lightning causes to needle telegraph circuits, more especially, is much more serious than the damage to the apparatus itself; and as nearly all the railways in this country adopt needle telegraphs on account of their simplicity, their telegraphic communication is very liable to serious interruption whenever storms occur. Needle telegraphs are now also very largely employed for train signalling, and the demagnetisation, or the reversal of the magnetism in instruments employed for this purpose, is really much more serious than in the case of instruments used for speaking; for when the traffic of a railway is controlled by the telegraph, the safety of the train depends in a great degree upon the correct working of the apparatus.

The increasing application of needle telegraphs on railways led the writer of this paper some few years since to direct his attention to the subject, with a view to producing a more reliable and more durable instrument. The conditions which it is desirable needle instruments, and more especially train-signalling instruments, should possess are almost self-evident to any one giving attention to the matter.

1. The instruments should be of a simple, strong, mechanical construction, so as not to be liable to derangement by the rough usage they are sometimes subjected to in signal boxes. 2. The magnetic needles should be incapable of demagnetisation. 3. The coils should be efficiently protected from being damaged by lightning.

In January, 1866, the author designed and constructed instruments which he believes to fulfil, in a great degree, the conditions to be desired in needle telegraphs.

1. In respect to the mechanical parts of the instrument, instead of attaching the metal bearings by means of screws or bolts to a wooden case, and making the commutator barrel part metal and part wood, substances which can never be permanently united, the inventor constructs the instrument case, the bearings, and the blocks or anvils, which limit the motion of the handle, and which have to bear the strain and concussion of cast iron, in one solid piece, so there are no parts to be shaken loose. The commutator barrel is also a solid piece of metal, and the contact springs are so arranged that, however, roughly the instrument may be handled, they cannot be subjected to more than a definite limited amount of strain.

2. The magnetic needles inside the coils are made of soft iron instead of magnetised tempered steel, and these are rendered magnetic by induction from permanent magnets in the neighbourhood of the coils. As the soft iron needles are magnetic only by virtue of the permanent magnets in their proximity, the influence of powerful currents induced by lightning can only be momentary.

3. The coils are protected from fusion by means of a novel protector, which the inventor terms a lightning bridge, as it forms a bridge for the high tension electricity to pass over. It is this bridge which the author more particularly desires to bring before the notice of the section.

It is a well-known fact that when a discharge of high tension electricity, such as that developed by a frictional machine, or by lightning, is passed through a loop of wire, the extremities of which nearly approach one another, although the wire loop may oppose but little actual resistance to the quantity of electricity developed, the discharge will leap across the space of air separating the extremities in preference to passing throughout the length of the loop. This arises from the momentary resistance which the wire opposes to polarisation or magnetisation, a resistance probably approaching to infinite resistance during an infinitely small interval of time, and the result is that, even in a vacuum protector, where the earth conductor and insulated points are enclosed in a partially exhausted chamber, the main body of the discharge will leap across the space of air separating the insulated conductors and the earth conductor outside the exhausted bulb; and in every case coming under the writer's notice, where lightning has struck wires protected by vacuum protectors, the insulated conductors and the earth conductor outside the exhausted chamber have been more or less burnt, indicating the passage of lightning.

The author, when experimenting with electric currents of varying degrees of tension, had observed the very great resistance which a loose mass of dust composed even of conducting matter will oppose to electric currents of moderate tension. With a tension of, say, fifty Daniell cells, no appreciable quantity will pass across the dust of blacklead or fine charcoal powder loosely arranged, even when the battery poles are approached very near to one another. If the tension be increased to, say, two or three hundred cells, the particles arrange themselves by electrical attraction close to one another, making good electrical contact, and forming a channel or bridge through which the electric current freely passes. When the tension was still further increased to six or seven hundred cells the author found the electricity would pass from one pole to the other through a considerable interval of the ordinary dust which we get in our rooms, and which is chiefly composed of minute particles of silica and aluminum mixed with more or less carbonaceous and earthy matters. Incandescent matter offers a very free passage to electrical discharge, as is indicated by the following experiments. The author placed masses of powdered blacklead and powdered wood charcoal into two small crucibles; no current would pass through these masses of powder whilst they were cold, however close the poles were approached, without actually touching. The battery employed in this experiment was only twelve cells. The crucibles were then heated to a red heat, and electricity freely passed through the heated powder, and on testing the resistance opposed by the heated particles, placing the poles 1in. apart, and employing only six cells, the average resistance opposed by the blacklead was only four British Association units, and that opposed by the wood charcoal five units. The average resistance of a needle telegraph coil may be taken at 300 units, or ohms, as they are now termed.

These observations go to show that an interval of dust separating two metallic conductors opposes practically a decreasing resistance to an increasing electrical tension, and that incandescent particles of carbon oppose about 1-60th part of the resistance opposed by a needle telegraph coil. Reasoning upon these data the author was led to construct what he terms a "lightning bridge," which he constructs in the following way: Two thick metal conductors terminating in points are inserted nsually in a piece of wood. These points approach one another within abont 1-18th of an inch in a chamber cnt in the middle of the wood. This bridge is placed in the electric circuit in the most direct course which the lightning can take, as shown in the diagram, Fig. 1, and the space separating the two points is filled loosely with powder, which is placed in the chamber, and surrounds and covers the extremities of the pointed conductor.

FIG. 1.

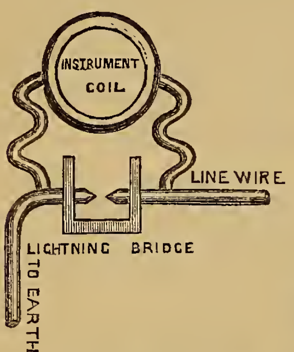
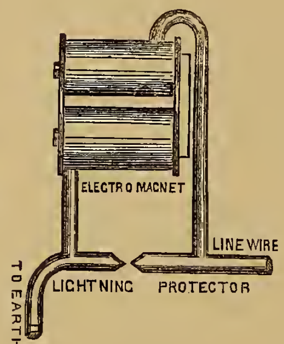


FIG. 2.



The powder employed consists of carbon (a conductor), and a non-conducting substance in a minute state of division. If we consider for a moment what must follow when lightning strikes the wires (keeping in view well-established laws), we shall find that the electric discharge passing throngh the telegraph coils is not momentary, but occnpies time. When the insulated telegraph wire is struck the effect of the electric discharge is to polarise and to magnetise the line wire throughout; after the discharge the wire returns to its normal unpolarised condition, but as is well-known the cessasion of the magnetisation althongh very rapid is not instantaneous, and as is also well-understood the effect of the wire, assuming its normal unmagnetic condition, will be to develop an electric current flowing in the same direction as the electric discharge which magnetised the wire. The tension of the current developed by the demagnetisation will be very great at its first development, and it will rapidly afterwards fall to zero. We therefore have, first, the main discharge of electricity of very high tension which passes by the shortest route, and which does not wait to polarise the coil wires, but leaps across a space of air to the earth conductor as the easier course, followed by a secondary current flowing in the same direction, but occupying time. The tension of this secondary current, althongh at first very high is not nearly so great as the lightning discharge. And the greater portion, if not the whole, of it will pass through the coils which oppose, when time is given, a much lesser resistance than the smallest possible space of air. It would, therefore, seem that when telegraph circuits protected by ordinary protectors are struck by lightning, it is to this secondary current and not to the main discharge the fusion must be attributed. The fusion of the platina wires in the vacuum protectors must also be attributed to this secondary current, and not to the main discharge. The coils of needle telegraphs are more frequently fused than those of other telegraphic apparatus in which electro-magnets are employed, and this is in the authors opinion a strong confirmation that the fusion of the coils is due to the secondary current developed by the demagnetisation of the line wire.

The relay coils nsed in other telegraph systems have soft iron cores which become magnetic when a current is passing through the coils. And a greater amount of magnetism is developed in the cores than in needle telegraph coils, but a very sensible time is occupied by the soft iron cores passing from the normal to a magnetised condition, and when the line wire of such a circuit is struck by lightning, the tendency of the secondary current developed by the demagnetisation of the line wire is to magnetise the soft iron cores. The momentary resistance these cores oppose to magnetisation is very great; the demagnetisation of the line wire, therefore, proceeds more slowly, the electricity generated by the demagnetisation being of a definite amount, the tension of the secondary current is proportionately reduced in accordauce with the time occupied by the demagnetisation, and the coils are not so liable to be fused. The retardation which the magnetisation of an electro-magnet opposes to the demagnetisation of another one is well-known, and is explained in "Culley's Handbook of Electric Telegraphy," page 210. The author refers to it because he is most anxious to advance only that which is the result of his own direct experiment, or is based upon well-established laws generally accepted by leading electricians. The action can be better illustrated by a diagram, Fig. 2, which represents a Morse telegraph circuit having a lightning protector connected to it.

The line wire of a telegraph circuit is only a continnation of the coil wires, and is rendered magnetic in the same way by electric polarisation, the chief and almost the only difference being that in the coils the magnetism is concentrated in a much smaller space. The force of the lightning may be regarded as irresistible, and if there were no other channel excepting the convolutions of the electro-magnets, it would pass through them. The lightning magnetises the line in its passage, and leaps the space separating the points of the protector, as the easier course, and does not magnetise the electro-magnets. Demagnetisation of the line wire, which always takes time, and which can be retarded, follows, and the resistance which the soft iron cores oppose to the assumption of the magnetised condition, does retard the demagnetised condition, does retard the demagnetisation of the line wire, redncing the tension of the secondary current.

Needle telegraph coils not having a mass of iron in them to be magnetised, demagnetisation of the line wire follows much more quickly; the secondary current is more intense, and the coils more often suffer. We have now to consider the behaviour of the lightning bridge in a circuit struck by lightning. The lightning finds in its direct path, not a space of air, but a bridge of powder, consisting of particles of conducting matter in close proximity to one another; it connects these under the inflnence of the discharge, and throws the particles into a highly incandescent state. Incandescent matter, as has been already demonstrated, offers a very free passage to electricity, and the secondary current developed by the demagnetisation finds an easier passage across the heated matter than through the coils.

The reason a powder consisting entirely or chiefly of conducting matter, cannot be safely employed, is that, althongh in the ordinary conditions of things it would be found to oppose a practically infinite resistance to the passage of electricity of the tension of ordinary working currents when a high tension discharge occurs, the particles under the influence of the discharge will generally be found to arrange themselves so closely as to make a conducting connection between the two points of the lightning bridge. This can be experimentally demonstrated by allowing the secondary currents developed by a Rhumkoff's coil to spark through a loose mass of blacklead. The crucial test, however, is the behaviour of the bridge in practice. These lightning bridges have been in use since January, 1866. More than four years, at the present time, there are upwards of 1,000 doing duty in this country alone, and not a single case has occurred of a coil being fused when protected by them. It is only right, however, to mention that three cases, but three cases only, have occurred where connection was made under the influence of electrical discharge between the two metallic points in the bridge. The protectors in which this occurred were amongst those first constructed, in which a larger proportion of conducting matter was employed than the inventor now adopts. The points also in those first constructed were approached to 1-50th of an inch from one another; and the author has no doubt, from an examination of the bridges afterwards, that under the influence of a high tension discharge, connection was made between the two metallic points by a bridge of conducting matter, arranged closely together, and if the instruments had been shaken to loosen the powder, all would have been put right. In one of these three cases—and it was the only one in which the anthor was supplied with the details—he ascertained that the protector was attached to a needle telegraph, having the ordinary magnetic needles made of tempered steel magnetised; and on the removal of the bridge after the discharge, so completely had the electricity been carried away by the bridge, that the magnetism of the magnetic needle was found not to have been affected.

As needle telegraphs are largely employed in this country, and as there is every probability that they will be still more largely used, it must be evident that it was very desirable to obtain an instrument which could not be demagnetised, and which was not liable to be damaged or interrupted by lightning; but attempts to advance generally meet with more or less prejudice and interested opposition, and the introduction by the author of these improvements has been no exception to what wonld seem to be a universal law.

The introdnction of the author's instruments did, however, make steady way. Many attempts were made to snpersede his coils; and in 1869 there was at least one other form in practical use, and there may have been others. The desirability of protectors for needle telegraphs was also recognised at this period.

In September, 1869, a change took place in the telegraphic administration of this country consequent upon the Government acquiring the telegraphs, and the Postmaster-General, by pnblic advertisement, invited tenders for telegraph apparatus, and, among the apparatus specified, samples were requested of needle telegraph instruments with soft iron needles, rendered magnetic by induction from permanent magnets.

This may be regarded as the first official recognition of induced magnet coils. Samples of coils of different forms having induced, magnetic needles were submitted by the leading manufacturers; the construction designed by the author was, however, found to be the most sensitive of those submitted. It was accordingly selected, and has been adopted. The author was the first to construct practically successful coils with induced magnets, and he has probably worked more earnestly in this direction than other telegraphic engineers; but he met with little encouragement when he first introduced them, which was in 1866. Four years only have elapsed since then, and the days of permanent magnetic needles for needle telegraphs are already numbered. There are now some thousands of induced magnet coils doing daily work, and the coils of the old pattern are being converted into induced magnet coils. There is every probability that in a very few years the substitution of induced magnetic needles for the so-called permanent ones will have become universal in this class of telegraphs. There are upwards of 1,000 of the author's lightning bridges doing duty in this country, but this does not bear a large proportion to the telegraphs of the United Kingdom. The protector, which lately appears to have found favour, and is probably the most extensively applied, consists of two silk wires wound side by side upon a bobbin. It was thought the lightning (as it has to pass through these wires before reaching the instrument coils) would take the shorter course of leaping through them, instead of passing throughout the length of the instrument coils, and the author has no doubt that the main discharge does take this shorter course. The coils are, however, found in practice not to escape fusion, but it is hoped by those who advocate this form of protector that they will be made efficient by increasing the length of the wire on the bobbins. The author thinks no very good result will be obtained in this way, but it remains to be seen, granting even that lengthening the protector wires will make them so far effective as to prevent the fusion of the coil wires. These protectors can scarcely then be considered to fulfil the conditions to be desired, for one of two things will probably take place—either the protector wires will be fused together by the passage of the lightning across, or the circuit will be divided, and in either case communication will be interrupted; and if there be several stations upon the same circuit, the fusion of the protector wires may take place at more than one station, and until they have been removed and reconnected communication throughout the circuit will be interrupted. The author is quite willing to leave the value of his lightning bridge to be decided upon its merits. Its design has been the result of patient investigation; the data upon which it has been constructed have all been obtained from direct experiment. It is simple in construction. It has been tested upon a considerable scale for upwards of four years, and the author claims upon the results obtained that the "bridge" possesses the conditions to be desired in a greater degree than any other protector he is acquainted with.

Appendix.

Experiments to test the Resistance opposed to the passage of Electricity by powdered conducting Matter.

Two crucibles were filled with blacklead powder (the best commercial blacklead used for domestic purposes). Two crucibles were filled with powdered charcoal obtained from a charcoal dealer. The battery poles of a 12-cell sulphate battery were placed half an inch apart in the powders, a horizontal galvanometer being included in the circuit, and no deflection was obtained either with the blacklead or the charcoal powder; the galvanometer employed gave a deflection 50 deg. with 12 cells through a resistance of 65,000 ohms. The crucibles were then heated to a full red heat, and the poles of the 12-cell battery placed in the heated powder, and the resistance opposed by the heated powder in each crucible measured. The wood charcoal gave a resistance never exceeding 7 ohms. The blacklead gave a resistance never exceeding 6 ohms. The crucibles were then removed from the fire and allowed to cool, and tested again some days afterwards; the powders were now found to conduct when cold. The wood charcoal powder gave a resistance continually varying and ranging between 2,000 and 500 ohms. The blacklead gave a more constant resistance ranging between 400 and 100 ohms.

The effect of highly heating charcoal and blacklead appears to be to make the particles more dense, and to bring them closer together, so that they conduct, and therefore, in the construction of the "bridge," it is necessary to mix sufficient non-conducting powder with the carbon to prevent the carbon particles from actually touching one another; these particles of non-conducting matter act in a somewhat analogous way, as the particles of non-combustible matter in Gale's gunpowder—they insulate particle from particle.

ON FAURE'S BATTERY.

By C. Becker.

Faure's element is a modification of that known as Bunsen's, the poles consisting of carbon in strong nitric acid and amalgamated zinc in dilute sulphuric acid. In Bunsen's ordinary form of carbon element the carbon pole is immersed in a vessel holding a considerable quantity of nitric acid, which, as it becomes de-oxidised by the electrolytic action of the current, liberates nitrous acid gas, which rises into the air, rendering it unwholesome to breathe, and destructive to most metallic apparatus in its neighbourhood. The purpose of Faure's battery is to obviate these drawbacks. This is effected by confining the nitric acid inside the carbon pole and allowing only sufficient acid to percolate through it, in order to keep up the necessary electrolytic action of the element. The carbon pole is made in the form of an ordinary bottle, and is provided with a carbon or platinum stopper, to which the binding screw of the pole is attached. This bottle, which fulfils at once the functions of both pole and porous diaphragm, is placed concentrically in the interior of a cylinder of amalgamated zinc. And the whole is contained in an earthenware jar. When set up for action the bottle is nearly filled with the nitric acid, and the space containing the zinc, between the bottle and the outer jar, to the required height with the dilute sulphuric acid. The slight liberation of gas within the bottle causes a sufficient pressure to be exerted upon the nitric acid to force it gradually through the carbon. In this way the exterior of the carbon pole remains immersed in a very thin layer of nitric acid immediately opposite to the zinc, which is in course of dissolution in the dilute sulphuric acid. In point of constancy this element is superior to either Bunsen's or Grove's, because the body of nitric acid remaining protected within the bottle does not become weakened, as is the case with those forms of elements in which the two fluids are exposed in larger quantities and separated by porous diaphragms. It acts also entirely without any disengagement of gas into the air, so that it may be used in any room without disagreeable consequences. A variety of forms might no doubt be given to these elements which would enable them to fulfill the desired object. Those which I have placed upon the table were designed and manufactured by Messrs. Elliott Brothers, and are found to be convenient for experimental purposes as well as for use in telegraph offices.

THE UTILISATION OF FIBROUS COTTON SEED.

By Mr. Thomas Rose.

In the present utilitarian age, not a few would be astonished to hear that a vegetable production which should be valuable is wasted, not merely by hundreds and thousands but by millions of tons. He referred to the fibrous cotton-seed, and the extent of the waste was conveyed with the knowledge that for every pound of cotton picked there were three pounds of seed grown; and its magnitude was even more apparent when they remembered that there was raised last year in America alone cotton to the extent of 3,000,000 bales. Taking an average of five bales to the ton, this would give no less than 1,800,000 tons of seed. From this deduct the quantity needed by planters, and there still remained a million and a-half tons available, and which had hitherto been of little value, lying for the most part where it was ginned to rot and spoil. This seed was composed of 50 per cent. kernel, which would yield about one-third oil and 50 per cent. husk (*i.e.*, shell with fibre adhering), and upon which fibre existed in the same relative proportion to the shell as the oil bore to the kernal. From this they gathered that the seed, now all but wasted, would produce no less than 250,000 tons of pure cotton, 250,000 tons of oil, and 500,000 tons of cattle-cake, the pecuniary loss to the community reaching twenty millions sterling. To show how the seed could be rendered available, he showed that the kernal was useful for obtaining oil, and the husk could be sent to the paper-mill, where it underwent a treatment by which the cotton was completely eliminated without injury to the delicate fibre, leaving it in such a condition that it formed a valuable material for paper-making, or other purpose to which cotton of short staple was suited. Now that all paper-making materials were so dear, and supplies of Esparto grass were failing and uncertain in quality, it was important to know that not only was there cotton-seed fibre procurable equal to present or prospective wants, but that the cotton from which the plant was cultivated—was of such great value that it could afford the heaviest cost of production without any fear of checking supplies; and there was still further security in the fact that cotton could never be grown without yielding two or three times its weight in seed. The writer afterwards went on to show how the kernel could be made to yield oil and a nutritious food for cattle in great quantities.

MANCHESTER STEAM USERS' ASSOCIATION.

CHIEF ENGINEER'S MONTHLY REPORT.

The last ordinary monthly meeting of the Executive Committee of this Association was held at the Offices, 41, Corporation-street, Manchester, on Tuesday, October 4th, 1870, Sir William Fairbairn, Bart., C.E., F.R.S., LL.D., &c., President, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, which on that occasion was for two months, and is given in abstract as follows :—

" During the past two months, 462 visits of inspection have been made, and 1,023 boilers examined, 676 externally, 13 internally, 11 in the flues, and 323 entirely, while in addition 3 boilcrs have been tested by hydraulic pressure. One of these hydraulic tests was an ordinary one, simply to ascertain the sufficiency of a boiler already in work, while in the other 2 cases the boilers were new ones, and were tested by hydraulic pressure, as well as specially examined, both as regards their construction and complement of fittings, before leaving the maker's yard. In the 1,023 boilers examined, 206 defects were discovered, 13 of them being dangerous. Furnaces out of shape, 6,—1 dangerons; fractures, 41,—1 dangerous; blistered plates, 21; internal corrosion, 51,—3 dangerons; external ditto, 15,—2 dangerous; internal grooving, 27; external ditto, 1; feed apparatns out of order, 1; water gauges ditto, 10,—2 dangerous; blow-ont apparatus ditto, 5; fusible plngs ditto, 2; safety-valves ditto, 3,—2 dangerous; pressure gauges ditto, 12; boilers without feed-back pressure valves, 8; cases of deficiency of water, 3, —2 dangerous.

" Explosions.

" On the present occasion I have seven explosions to report, by which 13 persons were killed and 26 others injured. Not one of these explosions sprung from boilers enrolled under this Association. The number of explosions from the commencement of the year amounts to 34, resulting in 63 deaths and in 77 cases of personal injury. It is more than possible, however, that some explosions may not have come under my notice, so that this list may not be complete. The following is a tabular statement of the explosions which have occurred during the past two months, while particulars will be found below :—

" Tabular Statement of Explosions from July 23rd, 1870, to September 23rd, inclusive.

Progressive No. for 1870.	Date.	General Description of Boiler.	Persons Killed.	Persons Injured.	Total.
28	July 29	Single-flued, or 'Cornish' Internally-fired	0	0	0
29	Aug. —	Superheater of Marine Boiler	1	0	1
30	Aug. 12	Vertical Water Pipe Externally-fired	0	0	0
31	Aug. 13	Vertical Fire Box Internally fired	4	5	9
32	Sept. 14	Plain Cylindrical, Egg-ended Externally-fired	4	20	24
33	Sept. 15	Vertical Water Pipe Externally-fired	1	0	1
34	Sept. 17	Plain Cylindrical, Egg-ended Externally-fired	3	1	4
		Total	13	26	39

" An Explosion from External Corrosion.

" No. 28 Explosion, by which fortunately no one was either killed or injured, occurred at a mine at twelve o'clock noon, on Friday, July 29th. The boiler, which was of the plain Cornish class, had a length of 26ft., a diameter of 5ft. 9in. in the shell, and 3ft. 6in. in the furnace tube, while the plates were seven-sixteenths of an inch in thickness, and the load upon the safety-valve about 35lb. per square inch. The boiler gave way in the external casing, a belt consisting of the first three widths of plate counting from the front end, and measuring 6ft. across, being ripped out of it, leaving the remainder intact. The explosion was dne to external corrosion, the plates all across the belt of plating that tore away, being seriously wasted, and in parts reduced in thickness to one thirty-second of an inch. The corrosion appears to have occurred at one of the side walls on which the boiler was set, and to have sprung from leakage that took place a little above the seating. It will be seen that this explosion is one of the simplest character, and that it might have been prevented by competent independent inspection.

" An Explosion springing from the Superheater of a Marine Boiler.

" No. 29 Explosion, by which one man was killed, occurred early in August on board a screw steamer lying in the Thames, and sprung from the rnpture of a superheater attached to the boiler. In this case I have bnt few particulars. An examination could not be made without an order, and though an officer of the Association made application to the agents in charge of the vessel, he was unsuccessful. I am informed, however, that the superheater was abont seven years old; that it was placed at the bottom of the funnel, and that it rent for a length of about 2ft. 6in. at a thin place in the plate, in consequence of which the funnel was blown down and one man killed. Althongh these details are so scanty, they suffice to show that superheaters can explode with fatal conseqnences, and this being so, it follows that they should be brought under periodical inspection as well as boilcrs.

" An Explosion from a bad Safety Valve.

" No 31 Explosion occurred at about one o'clock on the afternoon of Saturday, the 13th of August, at a brickyard, and resulted in the death of four persons, as well as in injnry to five others. The boiler was of cylindrical vertical constrnction with a high steam dome, placed on the top. It was fired internally, bnt surrounded with a circular casing of brickwork forming a flue for carrying the flames round the outside, after leaving the furnace. The height of the boiler, including the dome, was 10ft. 6in., and excluding it 6ft. 3in., while the diameter in the shell was 5ft., and in the furnace tube 3ft. 6in., the thickness of the plates being half an inch thronghout. The boiler gave way in the outer casing, which was rent away from the firebox, and torn into ten fragments, all the parts, along with the external casing of brickwork, being scattered in every direction, and many of them hurled to considerable distances. Somo of the bricks were thrown as far as a quarter of a mile, the manhole cover 170 yards, one piece of plate 145 yards, another 140 yards, another again 95 yards, another 60 yards and so on. The flight of these parts scems to have been as deadly as the discharge of a piece of artillery. One large fragment was shot into a shed, and falling upon a poor lad at work there, cut him open and killed him on the spot. Another piece of plate which fell within 3ft. of the one just referred to, cut down and killed another boy, while two other lads were so seriously scalded and otherwise hurt, that they died shortly after, added to which, five othcr persons were injured. It will be observed that the four victims of this explosion who lost their lives were all lads. One of them was 15 years of age, another 11, another 10, these three, it appears, being engaged at the works; while the fourth, who was younger still, had come to bring his brother's dinner, when he was overtaken by the catastrophe.

" With regard to the cause of the explosion, the boiler was badly made and badly equipped. It had been weakened at the base of the vertical steam dome, already referred to, by the plate being cut out to the entire diameter of the dome, so that there was a large gash measuring 2ft. 1in. in diameter. Added to this, the manhole was cut out close to the base of the steam dome, and not strengthened with any suitable monthpiece, or even with a wronght iron ring, so that, what with the dome hole, the manhole, and the rows of rivet holes, by far the greater part of the metal was cut away, and there was little or nothing left. The holes were running one into the other. But this was not all. There was but one safety-valve, and that a bad one. The maker had supplied the boiler without fittings, and the purchaser had worked in a small second-hand valve from an old boiler, loaded by a spring balance, which is a plan of loading that admits, unless special precautions are taken, of the valve being locked fast, and thus rendered useless simply by an extra turn of the screw. The Association's inspector who visited the scene of the catastrophe, naturally directed especial attention to this point; but just as he was doing so, a police officer interfered and prevented his getting the particulars he wanted. The inspector explained the nature of his errand, but in vain. This interruption was the more gratuitous, as the engineer engaged by tho coroner had already made an examination, and drawn np his report. In that report it is stated that the safety-valve was too small and dangerously defective. That the lever was loaded with a spring balance indexed to 50lb., bnt that it and the balance were calculated for a valve of nearly twico the diameter of the one used, and, consequently, when the index showed 50lb., the steam, when blowing off freely, wonld attain a pressure of as much as or more than 100lb. Also that this kind of valve was extremely liable, in incautious hands, to be locked and rendered utterly nseless, which the writer of the report cousidered had been the case in this instance.

Afterwards, in evidence, this witness repeated that he considered the safety-vale extremely defective, while the indications were wrong, and that this was sufficient to account for the explosion. From this evidence there seems no reason to dissent. Snch information as our inspecter was able to gain quite corroborated it, while the fact that the explosion occurred at the close of the dinner hour, during which the engine had been standing, is all in favour of the view that the explosion resulted from excessive pressure, more especially since there was no steam-gauge to show what the pressure actnally was. This explosion, may, therefore, be attribnted to malconstrnction, the boiler being both badly made and badly equipped.

"The jury brought in the following verdict:—'The jnry are of opinion that the explosion was the result of over pressure, caused by the safety-valve being too small, and ont of order. They think, so far as the evidence is concerned, that the deaths are accidental. At the same time, the jury strongly recommend the owner to employ more experienced hands in the working of the boiler for the future, and that a more competent party should inspect any boiler that may hereafter be intended to replace the exploded one, both before its working and when it is in operation.'

"This explosion might clearly have been prevented by competent inspection. The four lives lost were sacrificed on the altar of incompetency and commercial greed. Many boilers as dangerous as the one just described are now in nse, surrounded by workpeople in total ignorance of their danger. Their lives now tremble in the balance. By the next monthly meeting of this committee, the fate of several will be determined. There will be yet other explosions, other deaths, and other cases of serions injury to be recorded. The experience of the past renders this a matter of certainty, and the recurrence of explosions may be relied on as surely as the rising of the tide, the appearance of a new moon, or the rotation of the seasons. Yet this might all be prevented. The sufferers, however, are too poor and too ignorant to defend themselves, and therefore it becomes the imperative duty of those who have the requisite knowledge and requisite power to put a stop to these catastrophes, to interfere on their behalf.

"Another Explosion from the Treachery of the Plain Cylindrical Externally-fired Boiler.

"No. 32 Explosion, by which four persons were killed and twenty others injured, occurred at a little before four o'clock on the afternoon of Wednesday, September 14th, and sprung from a plain cylindrical, egg-ended, externally-fired boiler in nse at an ironworks. An officer of this Association has visited the scene of the catastrophe and taken full particulars; bnt, as the parties interested in the explosion are having one of the ruptured plates tested, it is thought well to defer detailed notice of this explosion till these experiments have been completed.

"Two Explosions from 'Patent Safety' Water Pipe Boilers.

"No. 30 and No. 33 Explosions are both so similar that they may be treated together. No. 30 Explosion, by which fortunately no one was either killed or injured, occurred at a weaving shed at half-past six o'clock on the morning of Friday, August 12th. No. 33 Explosion, by which one person was killed, occurred at a builder's at abont half-past six o'clock on the morning of Thursday, September 15th. The boilers, in both cases, were not of the ordinary mill type, but of peculiar construction, consisting of a number of vertical pipes in which the steam and hot water are contained, and round which the flames from the fire play. The tnbes are of wrought iron, and about 6ft. long by 6in. in diameter. Both these boilers gave way in one of the vertical water tnbes at the back, the rent in one case being a vertical one about 2ft. long, while the other was of a very similar character. In consequence of these rents the steam and hot water rushed out, blowing down in both cases some of the brickwork in which the boilers were set, and in one of them scalding the attendant to death. Unfortunately, information was not received of either of these explosions until some days after they had occurred, so that although an officer of this Association visited the scene of the catastrophes as soon as notice was received, he found that the ruptured tnbes had been removed, and was unable to gain full particulars. Under these circumstances it may be better to wait further consideration of these explosions till fuller details are obtained, and simply to record the fact that two explosions, one attended with fatal consequences, have sprung from 'patent safety' boilers, though comparatively new. It may be added, however, that it was stated at the inquest that the latter had been working for 18 months, and on account of leakage at the joints had been taken apart abont 6 months ago, and occasionally doctored since then with oatmeal and bran to keep it tight, while the other boiler had only been at work about six months, and fed with muddy water, with which it would appear these boilers are not able to cope.

"Another Explosion from the Treachery of the Plain Cylindrical Externally-fired Boiler.

"No. 34 Explosion, by which three persons were killed and one other injured, occurred at an ironworks at half-past eight o'clock on the morning of Saturday, September 17th. The boiler which was one of a range of four of similar construction set side by side, three of which were at work at the time of the explosion, was of the plain cylindrical, egg-ended, externally-fired class, and measured 33ft. in length by 4ft. 10in. in diameter, and three-eighths of an inch in the thickness of the plates, the pressure being 50lb. on the square inch. The boiler rent in two transversely, at the fifth circumferential seam of rivets conuting from the front, which fell abont 18in. behind the firebridge. On the occurrence of this rent the two sections of the boiler, being severed one from the other, were thrown in opposite directions, one of them to a distance of 120 yards.

"So many explosions of a similar character to this have been reported, and the tendency of this class of boiler to fail in this way so frequently pointed ont, that it need now only be said that this explosion is merely another illustration of the treachery of this description of boiler, more especially when the feed water is delivered cold, as in this case, within a few inches of the bottom of the shell and only a short distance behind the bridge. Repeated cases of injury to this class of boiler have been met with from this mode of feeding, and particulars of many of them given in these reports, while it is bnt a few years since that another boiler turned ont by the same maker as the one under consideration, burst with fatal results from this cause, so that even loss of life is powerless to persuade some boiler makers to learn wisdom.

INSTITUTION OF CIVIL ENGINEERS.

SUBJECTS FOR PREMIUMS, SESSION 1870-71.

The Council of the Institution of Civil Engineers invite communications on the subjects comprised in the following list, as well as upon others; such as 1° Authentic Details of the Progress of any Work in Civil Engineering, as far as absolutely executed (Smeaton's Account of the Eddystone Lighthouse may be taken as an example); 2° Descriptions of Engines and Machines of various kinds; or 3° Practical Essays on Subjects connected with Engineering, as, for instance, Metallurgy. For approved Original Communications, the Council will be prepared to to award the Premiums arising out of special funds devoted for the purpose:—

1. On the strength and resistance of materials, practically and experimentally considered; 2. On the theory and practical design of retaining walls; 3. On steam and hydraulic cranes, and on the application of steam power in the execution of public works; 4. On the different systems and the results of the use of road traction engines; 5. On land-slips, with the best means of preventing, or arresting them, with examples; 6. On the gauge of railways; 7. On the principles to be observed in laying-out lines of railway through mountainous countries, with examples of their application in the Alps, the Pyrenees, the Indian Ghâts, the Rocky Mountains of America, and similar localities; 8. On peculiarities in the systems of construction adopted for railways in different countries; 9. On the systems of fixed signals at present in use on railways; 10. Descriptions of modern locomotive engines, designed with a view to cheapness of construction, durability, and facility of repair; 11. Description of continuous breaks which have been extensively employed on railways, and the general results; 12. On the principles which should be observed in laying out the streets and thoroughfares of towns, or of the successive extensions of large towns and cities; 13. On the most suitable materials for, and the best mode of formation of, the surfaces of the streets of large towns; 14. On the advantages and disadvantages of subways, for gas and water mains, and for other similar purposes; 15. Accounts of existing water-works; including the sources of supply, a description of the different modes of collecting and filtering water, the distribution to the consumers, and the general practical results; 16. On the theory and practical design of pumps, and other machines for raising water; as well as of turbines, and of water pressure engines; 17. On the principles applicable to the drainage of towns, and the disposal of the sewage; 18. On the employment of steam power in agriculture; 19. On the theory and practice of the modern methods of warming and ventilating large buildings; 20. On the supply of gaseous fuel in towns for heating purposes; 21. On the design and construction of gas works, with a view to the manufacture of gas of high illuminating power, free from sulphur compounds, especially sulphide of carbon; and on the most economical system of distribution of gas, and the best modes of illumination in streets and buildings; 22. On the theory of Heat applied to steam engines; 23. On the theory of condensation in steam engines, and the total effects upon the efficiency of a steam engine of the various modes of producing condensation; 24. On the practical employment of heated air as a motive power; 25. Description of successfully applied gas engines; 26. On the maintenance, by sluicing, of the harbours on the coasts of France, Belgium, and Holland; 27. Description of the sea

works at the mouth of the River Maas, and the effects produced thereby; 28. On the constrnction of tidal, or other dams, in a constant, or variable depth of water; and on the use of cast and wrought iron in their construction; 29. On the arrangement and construction of floating landing-stages, for passenger and other traffic, with existing examples; 30. On the different systems of swing, lifting, and other opening bridges, with existing examples; and on the theory and practical design of machinery for working opening bridges; 31. On the present condition of knowledge relating to the friction of vessels passing throngh water at different velocities, with suggestions for future research, either theoretical or experimental; 32. On the design and details of construction of ships of war, having regard to their armour, ordnance, mode of propulsion, and machinery; 33. On the design and the materials for the construction of land fortifications; 34. On the measures to be adopted for protecting iron and iron ships from corrosion; 35. On steel, and its present position as regards production and application; 36. On the safe working strength of oast and malleable iron and steel, inclnding the results of experiments on the elastic limit of long bars of iron, and on the rate of decay by rusting, &c., and how far vibration or prolonged fatigue affects the strength of railway axles, chains, shafts, bc.; 37. On modern progress in telegraphic engineering, including a notice of the theoretical date upon which that progress has been based; as well as a description of the improvements in the construction of land and sea lines, and in the working instruments; 38. On the methods of producing artificial cold and ice by the conversion of mechanical force.

The council will be glad to receive, for the purpose of forming an "Appendix" to the minutes of proceedings, the details and results of any experiments or observations, on subjects connected with engineering science, or practice.

The council will not consider themselves bound to award any premium, should the communication not be of adeqnate merit, but they will award more than one premium, should there be several communications on the same subject deserving this mark of distinction. It is to be understood that, in awarding the premiums, no distinction will be made, whether the communication has been received from a member, or an associate of the institution, or from any other person, whether a native, or a foreigner.

The communications must be forwarded, on or before the 1st of February, 1871, to the house of the Institution, No. 25, Great George Street, Westminster, S.W., where copies of this paper, and any further information, may be obtained.

Charles Manby, Hon. Sec.
James Forrest, Sec.

The list of members of this Institntion corrected to the 1st inst., has just been issued. At that date there were on the books 16 Honorary Members, 699 Members, 994 Associates and 176 Students, making a total of 1,885 of all classes. During the last three months the deaths have been recorded of three members, viz.: Messrs. John Braithwaite, Samuel Dobson and William Alexander Provis, as well as of five associates, viz.: Sir John Thwaites, Bart., Lient. Col. Julian St. John Hovenden, R.E., Messrs. William Gammon, George Houghton, and George Barnard Townsend, while one student has been permitted to retire. In the period referred to, no addition has been made to the list, as the meetings have been suspended during the recess.

SOCIAL SCIENCE CONGRESS.—MEETING AT NEWCASTLE.

THE WATER SUPPLY OF THE DISTRICT.

By Mr. P. Walter Meik.

As the supply of pure water is one of the most essential requirements for the maintenance of good health in populons districts, it will perhaps not be out of place at the present meeting of the Social Science Congress to give a short account of the manner in which the district in and around Newcastle-on-Tyne is supplied in this respect. The great northern coal field of Northumberland and Durham—of which Newcastle may be considered the oentre and metropolis—being now almost fully occnpied by extensive working colleries, round which large masses of population are localised, and these colliery towns being placed more with regard to the convenience of the colleries than to the natural facilities which have led to the establishment and growth of villages and towns of a more agricultural character, the introduction of pure water to the district has become a matter of considerable importance, and one which mnst be carried out npon a regular and well defined system. The natural sources of water supply for the district referred to, wonld, under ordinary circumstances, have been the springs and surface water within its own area, but in consequence of the extensive mining and manufacturing operations carried on in the coal field, these sonrces have been abstracted and polluted to such an extent as to render it necessary to have recourse to other means of providing the inhabitants with an efficient snpply of pure water. The great northern coal field occupies the principal portion of East Durham and Northumberland, as far north as the River Coquet, and comprises within its area the towns of Newcastle, Gateshead, North and South Shields, Blyth, Sunderland, Durham and Seaham, besides many large mining villages. The principal portion of the Durham coal field, viz., that situate between the boundaries of the magnesian limestone strata, is supplied with water by the Sunderland and South Shields Water Company, from deep wells sunk within its own area. These wells are sunk through the overlying limestone into a bed of yellow sand, geologically known as the "lower new red sandstone." This stratum comes immediately above the coal measures, and has proved a source of great difficnlty to all the colleries which have been sunk through it, on account of the immense qnantity of water which it contains. The limestone varies in thickness from about 100ft. to 300ft., and the company have already sunk four wells through it, at distances of about two miles apart, in the neighbourhood of Sunderland, the central and and most important town in their district. The immense underground reservoir which this sand-bed appears to be, places at the command of the company what may be termed a practically inexhaustible source of supply. The present pumping stations are no doubt capable of supplying the requirements of the community for some years to come, and, when these are fully developed, and the company have sunk the other two wells for which they have lately obtained powers, there is every probability that the immense resources of this water-bearing stratum will not even then be taxed to their fullest extent. The population supplied at present by the company may be taken at about 150,000, and the daily consumption at $2\frac{3}{4}$ millions of gallons—or at the rate of 18 gallons per head. This small consumption per head may be considered a remarkable feature in the working of the company, and one which has in no small degree contributed to the excellent position in which it now stands. I think there is only one town in England which has a less consumption per head than Sunderland, and I believe that is mainly owing to the strict supervision maintained, the excellence of the fittings, and the general carefulness of the consumers; at all events, the supply is constantly maintained, day and night, and there has never been any complaint of the scarcity of water. As might naturally be expected from its origin, the water is of a very hard description—its hardness being perhaps as great as any in the kingdom. Its entire freedom, however, from organic impurity renders it admirably adapted to the human constitution, although it is not of the most economical kind for ordinary domestic and culinary purposes. I am aware that it is a matter which has been very strongly discnssed of late years, whether hard or soft water is most conducive to health, and I think that the instance of this district being amongst the most healthy in the kingdom might prove a strong argument that hard water is, at all events, not prejndicial to human life. By the recent returns it is evidenced that the death-rate in Sunderland is, with one exception, the lowest of that of the seventeen largest towns in the kingdom. We may therefore dismiss this part of the subject by saying that the principal portion of the Durham coal field is amply provided with a supply of good water for many years to come. With regard to the supply of water to that part of the coal field which is sitnate in Northumberland, I may first notice the district served by the Newcastle and Gateshead Water Company, comprising the towns of Newcastle and Gateshead, the north margin of the river Tyne nearly to Shields, with the surrounding neighbourhood as far north as the large colleries of Killingworth and Seaton Burn. The population supplied by the company may be estimated at 160,000, and the daily consumption at from five to six millions of gallons, or at the rate of from 30 to 38 gallons per head. The company derive this snpply partly from gathering grounds in the upper feeders of the Rivers North Tyne, Rede, and Blyth, and partly by pumping from the river Tyne at a point near Newburn. The area of the gathering ground is about 27 square miles, and the total rainfall, I believe, about 27in. per annum. The water is collected by an aqueduct running along the slope of the hills, and intercepting the streams at an elevation suitable for gravitation. The aqueduct conveys it to storage reservoirs at Whittle Dene, near Harlow Hill, a point on the Roman Wall, from whence it is conveyed by pipes to Newcastle for distribution. The Whittle Dene water is good in quality, containing about 22 or 23 degrees of solid impurity. The water obtained from the Tyne is not of the most suitable description, contaminated, as it must be, by the sewage of Hexham and other large and popnlous places above the point of abstraction. The company are at present, however, endeavouring to augment the supply from the Whittle Dene works by the construction of an additional store reservoir at Hallington, by this means hoping to impound a larger proportion of the rainfall of their watershed. At present the water pumped from the Tyne constitutes in summer about, I believe, one-half of the whole supply. With the exception of the borough of Tynemouth, which is supplied by a small local company, there does not exist any regular or efficient system of supply to the large population of the remainder of the Northumberland coal mining district. The parish of Tynemouth above referred to contains a population of from forty to fifty thousand, and the supply is derived from wells and collecting tanks in the immediate vicinity of the town of North Shields. The quality is not excellent, and in dry weather the quantity is far from sufficient for the wants of the community, and as the population is rapidly increasing it will be necessary at no distant date to seek for additional supplies from extraneous sources.

With regard to the remainder of the mining district of Northumberland it may be observed that the necessity of a comprehensive system of water supply has been for some time increasingly felt. It has, therefore, for a length of time been in agitation to establish a company for the purpose of bringing into this district an abundant supply of pure water from a source where it is never likely hereafter to be contaminated or abstracted. With this view a company has recently been formed, and their prospectus is now before the public; and it will, perhaps, not be out of place for me to give a brief outline of their proposed scheme. The company do not propose to interfere with the works of any existing companies, but will take powers to furnish such companies, as well as local government boards, colliery owners, and large consumers generally with water for their respective districts, town-ships, and villages, in lieu of or supplementary to their present supplies. Such being the arrangements proposed, and seeing that the company will be in a position to furnish sufficient water for the whole population of the district, they hope to secure the active co-operation of all companies, boards, and proprietors interested in the provision of an adequate supply of water to their respective localities. The population at this time, exclusive of Tynemouth, is estimated at 40,000; to which, adding 50 per cent. for future increase, a total of 60,000 inhabitants will require to be provided for. The Newcastle and Gateshead Water Company has, by impounding the head waters of the Pont (a tributary of the Blyth) for consumption in the water shed of the Tyne, so far trenched upon the natural facilities of the gravitating district of the Pont and Blyth as to render it necessary to have recourse to the head waters of the Wansbeck; these, fortunately, drain an area of upwards of 45 square miles, at a minimum elevation of 470ft. above the level of the sea. It is, however, proposed at present to impound, by means of reservoirs placed 470ft. above the level of the sea, at or near Ronghlees and Newbiggin farms only the head waters of the river Font, the northern tributary of the Wansbeck, which drains an area of 13 square miles of the millstone grit formation, on the southern and eastern sides of the Simonside Hills; a formation which, being wholly of sandstone, yields a supply of the purest and softest water, situate in a district in which there is no village or other source of contamination. From the reservoir at Ronghlees it is proposed to convey the water by an open aqueduct; to a service reservoir near Morpeth, there to be filtered, and thence conveyed to Morpeth, Ewart Hill, near Bedlington, and to Horton Hill, from which two last points the parishes of Bedlington and Horton and the towns and districts of Cowpen, Blyth, and Newbiggin will be supplied; thence it is further proposed to carry the main pipes through the district comprising Seaton Delaval, Cramlington, Seaton Sluice, Hartley, Seghill, Holywell, Backworth, and Earsdon, supplying these places in detail. The ultimate requirements of the future population of this district may be taken at 20 gallons per head, or an aggregate of 1,200,000 gallons per day. The cost of the works is estimated at £75,000, or about 25s. per head of the population, an outlay below the ordinary cost of water supply. The above remarks do not include the borough of Tynemouth, but should this be included, the capital amount will be increased to about £100,000, and the population eventually to be supplied to about 120,000, which will give a proportionate reduction of the cost per head over the entire district, and in this case the working expenses would be but slightly increased. In conclusion, I may perhaps be allowed to state that in the present condition of the rivers of this country, where they pass through the midst of large populations, owing to the pollution of such rivers by the drainage of agricultural land, dwelling houses, and the fouling by manufacturing purposes, it is highly necessary that the districts to be supplied with pure water should, as far as possible, unite in carrying out large and comprehensive schemes which it would otherwise be out of the power of small localities to carry out for themselves individually. The future sources of supply in this country would seem to be in a great measure limited to deep wells beyond the reach of surface pollution, and gathering grounds on high elevations at the sources of our rivers. From the superabundance of the winter rainfall there is no doubt that an ample supply could be stored for all large towns. With this view I think the conclusions arrived at by the last Royal Commission on Water Supply are deserving of great consideration. "That in the introduction of any provincial water bill into Parliament attention should be drawn to the practicability of making the measure applicable to as extensive a district as possible, and not merely to any particular town. That when any town or district is supplied by a line or a conduit from a distance provision ought to be made for the supply of all places along such line."

SOUTH WALES INSTITUTE OF ENGINEERS.

INAUGURAL ADDRESS.

By Mr. T. W. LEWIS, (Mardy, Aberdare), President.

It has been the custom for some years past for the president at his first meeting to give some information as to our financial position, the number of members, &c., as well as to review the work done by the Institute generally. I am, therefore, obliged to trouble you with a few remarks, but I promise that they shall be brief. This Institute has now been in existence about thirteen years, and during that time has steadily advanced, so that, for some time past, it has taken up a most important position in this part of the kingdom, including among its members, as it does, nearly the whole of those engaged in the active management of the different operations, in connection with our staple trades of iron and coal in this district. The present number of members is nearly 200, and I am happy to inform you that we shall have a fund of about £1,000 to our credit, when the subscriptions now due are received. Of this amount £649 13s. 2d. has been invested in the names of trustees; and the remainder will also be placed at interest, as soon as this year's subscriptions are paid. The council have, as you are aware, on more than one occasion, had under consideration the best mode of using the money in hand, having regard to the objects for which the Institute was originally established. A great many of the members have been in favour of expending the money upon an erection wherein we could hold our meetings, and at the same time have the necessary accommodation for depositing and arranging geological specimens, minerals, models of machinery, and various objects of interest; and also have a library in connection with it—but up to this time the majority have considered such a step somewhat premature. I am induced to mention this at present with the view of getting the members to think the matter over, and to consider the best scheme for utilising the present funds, and, if necessary, augmenting them in some way in order to establish a museum and library, with place for meeting, as I believe there can be but little difference of opinion amongst us, as to the increased advantages such an erection would confer upon the Institute, as well as this district generally. Referring to the papers which have been read and discussed from time to time, I find that my predecessor (Mr. Bedlington) reviewed them so fully only a short time ago, that I have little or nothing to say; but, with your permission, I should like to mention a few matters which, in my opinion, we should do well to re-open, and others that it would be interesting as well as advantageous to the district if the Institute took them under consideration. Among the first is that of the economic value of fuel. A very able paper upon this subject was contributed to this Institute in August, 1860, but in consequence of the writer's inability to attend the meetings, the matter was not discussed so fully as it deserved. Without going into the theoretic value of coal, and the enormous waste set forth in that paper; it appears to me that a very great saving is to be effected by a little more attention to the construction of our boilers, the amount of boiler power, provision for heating the water, preventing the radiation and loss of heat, the general arrangements in the every-day practice of our mechanical engineers. The quantity of fuel that has been wasted in the South Wales district is perfectly astounding; and I am sure, if I were to give figures, they would not be credited. It no doubt arose to a very great extent from the abundance and cheapness of the coal, for while large coal was being consumed here regardless of quantity, and without any effort made to preserve and utilise the heat obtained, other manufacturing districts, not blessed with fuel under their feet, were (in consequence of its comparatively high price) obliged to devise means for obtaining two and three times the work out of every ton of coal, that we did here—and also to consume their small coal and utilise gases for heating. Keen competition and the low price of iron, however, forced our ironmasters to the use of their waste gases, hot blast, and small coal in the manufacture of iron; and thus effect a very great saving in fuel—but there is still very much to be done in reducing the quantity of fuel wasted in the getting up of steam, and in preserving the power when once obtained. Great economy might be realised even with our present system by increased boiler power—improved draught—so as to consume small coal and refuse, the heating of the feed water by the exhaust steam, and the waste heat on its way to the stack—the effectual covering of all the boilers, steam pipes, cylinders, &c.: but we should not rest satisfied until we have a much more perfect form of boiler, whereby only about $1\frac{1}{2}$ to 2lb. of coal, per horse power per hour, would be consumed. Even the arrangements common in this district may, by a comparatively small cost, be improved so as to reduce the consumption of coal one half. There are several places within my own knowledge, where by improvements such as I have sketched out, the consumption of fuel is now 50 per cent. less than formerly—and small coal is used instead of large. The matter is one of national importance, inasmuch as we are wasting 50 per cent. of the very material which has really been the means of making this country the seat of manufacture for the greater portion of the world; and of now holding its own with the manufacturing centres on the Continent; but to us engaged in the getting, using, and disposing of the coal, it must present itself most forcibly, with the constantly increasing tendency to run up the cost of getting coal in this district. Even if a saving of 25 per cent. could be effected in the coal consumed for steam purposes in the South Wales mineral basin alone, the value of it per annum would represent above £105,000. The consumption per horse-power per hour even then would be far in excess of some of the improved engines and boilers now used in districts where fuel costs twice or thrice what it does here. In fact, there are some engine and boiler makers that now guarantee their engines and boilers not to consume more than 1½lb. per horse-power per hour, while a great many of our engines in this district consume 8lb. to 10lb. per horse-power per hour. With these facts before us, although the contrast may to some extent be modified according to circumstances, I hardly need dwell upon the desirability of the Institute again taking into consideration and thoroughly investigating this important question of the most economical mode of using our fuel. Another subject, closely allied to the use of fuel, is that of the large proportion of coal lost in working, and left underground, upon which a paper was read before this Institute in the year 1861. Although very great improvement has taken place in a portion of the South Wales mineral basin in this respect since the introduction of the long-wall system (which I may here mention owes its general adoption in this district to the papers and discussions of this Institute, and for which all interested in the minerals, both as landlords and tenants, are much indebted), still a very large proportion of coal is left underground, amounting to an average of at least 18 per cent. This is again a very serious loss, and deserves most careful attention.

A great many appliances have been tried from time to time, worked by air, by water, and steam, for the purpose of holing, cutting, and bringing the coal down, in lieu of manual labour, having for their object the reduction in the cost of getting the coal, and securing the greatest possible proportion of large coal; but up to this time the success of most of them has been questionable, for various reasons which I need not here dwell upon. However, it appears from repeated trials that have been made in different seams in several districts, that some of the most recent coal-getting machines are likely to prove successful in reducing the loss in small coal in hard seams, as well as doing away with the necessity of blasting coal, which, as you are aware, is unfortunately a fruitful source of accidents. I will not weary you with the details of either machine, but I may say that the power applied is very simple, being a small quantity of water forced in by an hydraulic ram, and exerting a pressure of above 12 tons per square inch, which brings the coal down in large blocks. These machines may be carried about from stall to stall, and are easily worked by unskilled men, and although there are but few of them so far in general use, yet there appears no doubt that the principle is the best yet tried; and their introduction (or improvements upon them) seems to be only a work of time, as their are several advantages attending their use, besides placing colliery owners less dependent upon their colliers. My principal object in referring to them here is to state that in certain seams, more especially those requiring holing in the coal, a very great saving is effected in the quantity of small made; and where they are used instead of powder the small is reduced, and the large is obtained in a very much better condition, not being shattered through as coal blown down by powder is generally found to be. Several of the machines are at work in this district, and, considering the importance of reducing the enormous loss daily going on at our collieries, independent of the advantage alleged by the patentees in the cost of getting the coal, there can be no doubt as to the desirability of having the matter fully considered and discussed by this Institute. I should not omit mentioning, while on this question of small coal, that the introduction of washing machines will enable a great deal of our small coal, now comparatively worthless, being brought into use, and that the paper upon those machines, now before the Institute, deserves the fullest consideration and discussion.

Bearing upon this small-coal matter, is another, very materially affecting the interest of all concerned in the steam coal trade of this district, *i.e.*, the enormous loss in small coal in the transit from the working face to the shipping port. This loss is a most serious one, and very considerably depreciates the value of mineral property—as well as the collieries upon this description of coal, in this immediate locality—arising, to a very great extent, from the peculiar fracture of the coal, and the unnecessary extent that the screening and double screening of the coal has grown to during the last fourteen years, whereby about nine per cent. of small is taken out by passing the coal over the screens at the colliery, and eight to ten per cent. more extracted by means of double screening at the port. Some efforts have been made with the view of reducing the breakage caused by shipping the coal from the colliers' trams into the wagons by improved screens, and also at the port, by means of anti-breakage apparatus and recently by hydraulic cranes, for dropping the coal into the hold of the vessel in barrows; but there is still, with all the care exercised, an enormous loss, so much so that on an average every ton of coal *in situ* is by the means now generally adopted reduced to about 14 cwt. of large coal on board ship (assuming only 24 miles of road to port), the remainder being made up of 1.3 cwt. of small coal at port, 1.4 cwt. of small on the colliery bank, and 3.6 cwt. left underground, the net realised being 13.7 cwt. of large coal, and about 2.7 cwt. of small coal. Putting a money value upon this process: assuming a seam of coal in a mineral property to be worked out at the rate of 300 tons per day, the present result of a year's working is as follows:—

90,000 tons of large coal, extracted from the property worth—say 7s. 6d. per ton, at pit's mouth		£ 32,750
61,114 tons of large coal f.o.b., say at Cardiff, at a price equal to 7s. 6d. per ton at colliery	22,917	
6,642 tons of small coal at colliery, at 2s. per ton	664	
6,044 tons of small coal at Cardiff, at a price equal to 2s. per ton at the colliery	604	
	24,185	
Loss per annum		£8,565

I am aware that this is an extreme mode of stating the question, inasmuch as it is practically impossible to get the coal and remove it without a certain loss, but it is useful as an illustration of the gross waste of property daily taking place among us by the present barbarous mode of treating the coal, and to show that an effort should be made to reduce this enormous loss to the minimum which ought not to exceed one-half of what it is at present—or 12 to 15 per cent. It is a most difficult matter to grapple, and requires great consideration, but without it is brought home to those interested in the shape of pounds, shillings, and pence, there is but little hope of any attempt being made to alleviate the evil. What we want first of all is to reduce the loss in getting the coal, then to secure the coal filled clean, and have it handled as little as possible between the working face and the port. Of course, if it were practicable for the coal to be filled into such tubs in the workings as could be sent right to the ship, the minimum breakage would be attained. Next to that would be the sending of the coal from the colliery, and screening it only at the port, by which, in my opinion, a great saving would be effected in the gross small made. There are many difficulties to be dealt with, whatever change is attempted; but the present losses are so enormous that if only a small percentage can be saved, it would represent a large sum per annum on the working of an average steam coal colliery, and leave a margin to cover the additional expenses and trouble that extra care and a change in the manipulation would entail. This matter is second to none in importance in our steam coal district, and this Institute would, in my opinion, sadly fail in its duties if such enormous losses are allowed to go on, without, at all events, having the matter fully considered and discussed with the view, as far as possible, of remedying the present defects. Before leaving this subject, I shall call attention to a paper recently supplied to the Institute upon large and small trams, which elicited a great deal of discussion, but hardly as much as its importance merited; and it would, therefore, be very desirable to have the whole subject reopened with the view of getting more information as to the experience with all the trams used in this district, having regard not only to the cost of working, but also to the effect upon the quantity of large coal obtained.

Underground haulage has been treated upon in several papers, but we have had little or no information about what appears to be, with but few exceptions, the most economical as far as the cost of maintenance and working charges are concerned, viz., the endless chain system, which is at work in a few places in this district but most extensively in Lancashire. There are doubtless very great advantages attending its use, but considering that its adoption necessitates double roads, the difficulties we have to contend with in our underground workings, in bad roofs, and in keeping up the sides in our principal seams, together with the alterations which it would necessitate in our trams, I am afraid the extra expense would more than cover the advantages to be derived from its adoption in this district; however, there is no reason why it may not be introduced extensively in our surface operations. But there is very much to be done here with the tail rope and other systems of underground haulage in which we are far behind the best collieries in other districts, and which must have more of our attention as the length of haulage increases and our collieries become deeper and more extensive generally.

Several contributions have been made to our proceedings respecting the ventilation of mines, but so far as I have been able to ascertain, the proper distribution of air in mines, having regard to the number of splits, the length of the splits, and relative quantities for the several splits, does not seem to have been treated upon in either of the papers. Next to providing an ample quantity of air, to circulate between the downcast (through the workings) and the upcast shaft, is the most economical distribution of it through the several districts of the mine; and I am inclined to think that this important subject has not received the consideration which it merits at some of our collieries in this district; so that it would be very desirable to have it treated upon, by some of the managers of our largest collieries, where the splitting of air is necessarily carried out to a great extent.

The working of thin seams of coal has had but little attention in this district as compared with what is done in the Bristol and Somerset coal-fields. Up to this time it has been the practice in this immediate locality to leave unworked, seams of about 2ft. 6in. and under, but now that the principal or most remunerative seams of coal are becoming exhausted at some of the collieries on the crop, we shall have to turn our attention to the getting of the coal in the thinner seams down to 2ft., and even 18in. thick. This, as well as the order in which the seams of coal under a property should be worked, and the effect that the working of one seam has upon the quality and upon the cost of getting seams immediately above and below, is deserving of more deliberation; indeed, the latter is most important, as a great many of the difficulties to be contended with in the working of seams comparatively near together (from bad roofs, and various other obstacles tending greatly to increase the working of the coal) arise, to a very great extent, from the working of the seams regardless of order or precedence. There is such a variety of circumstances to be considered, which vary very much even in adjoining collieries, that it is difficult to lay down fixed rules; but if careful observations were made by colliery managers working the various seams in different order, and a record of them, together with the thickness and nature of the intermediate strata, quantity of gas, &c., was communicated to the Institute, there can be no doubt that some conclusions would be arrived at which would prove of very great benefit to the district.

Another matter which does not seem to have had much attention is that of the best mode of opening out collieries in maiden districts, referring more especially to our steam coals, in localities where the gases have not been tapped by the crop workings. A great difference of opinion exists as to the best mode of proceeding, having regard to the freeing of the gases, in a manner so as to insure the least possible risk of explosions. Many very serious accidents have occurred in such operations, in fact, most of the great explosions during the last 30 years; and, considering that we shall have to sink pits and open out collieries in a great many of our valleys, where there has been no opportunity of crop workings, I think the Institute should look upon this subject as one of the most pressing upon its attention. It has been the practice of the North of England Institute of Engineers, whenever an explosion of any magnitude has unfortunately taken place in their district, to arrange for a paper to be read, giving a detailed account, as far as the facts could be ascertained, of the whole of the circumstances, whereupon discussions have taken place with the view of determining as far as possible the causes of the accidents, and considering the means necessary to be adopted for preventing a recurrence. Such papers, describing the means adopted for restoring the ventilation, getting the workings into order, putting out standing fires, and of overcoming various difficulties consequent upon such events, would be of great practical benefit to colliery viewers, and it has occurred to me that we should do well to follow the footsteps of our sister Institute in the North in this matter.

The next subject having an important bearing upon the conduct of collieries in this district is the question of single or double shift, which was brought before the Institute a few years ago and fully discussed. The conclusions arrived at then were, if I mistake not, altogether in favour of double shift, but the difficulty of introducing it seemed at that time insurmountable. The matter was so thoroughly ventilated at the time, and the advantages with regard to reducing the risk of accidents were so clearly set forth, that I need not here dwell upon it, and my only object in now referring to it is for the purpose of suggesting whether it would not be advisable to have the discussion reopened, with the view of considering in what way so desirable a change could be best brought about.

The Institute has had very little, if any, information contributed upon the sinking and tubbing of shafts, and now that sinkings of much greater depth will have to be made to win our deep minerals, it would be interesting to have these subjects well discussed. For although we are not beset with such difficulties as have to be contended with in some of the deep pits in other coal-fields, still, in some situations, a great thickness of sand and gravel, with comparatively large quantities of water, is met with, and it would be advantageous to have a paper upon sinking and tubbing by some one having had practical experience in such works. Very able papers have been supplied upon various parts of the South Wales coal-field, as also upon the quantity of unworked coal in the whole of the basin; we need not trouble ourselves about the latter until the report of the coal commission is out, when I have no doubt there will be a great deal of discussion as to the conclusions arrived at with regard to the quantity of coal as well as the identity of the seams. But we have had little or no particulars about the eastern or western portion of the mineral basin, nor has there been any upon the interesting subject of the causes of the changes in the quality of the various seams of coal from east to west, nor upon the identity of the various seams of coal and ironstone, together with the most prominent features of the coal-field (that is, the Upper and Lower Pennant Rocks), all of which would be most interesting subjects.

There is another matter in connection with our mineral field which it would be exceedingly desirable to place on record, that is, an account of the faults, washouts, and other disturbances proved by the various operations. Doubtless, there would be some objection to going much into detail on this subject, as it might probably tend to depreciate the value of properties containing them; but there would be no difficulty in describing the general features with the probably direction and extent, &c., so that the information may prove useful in future explorations.

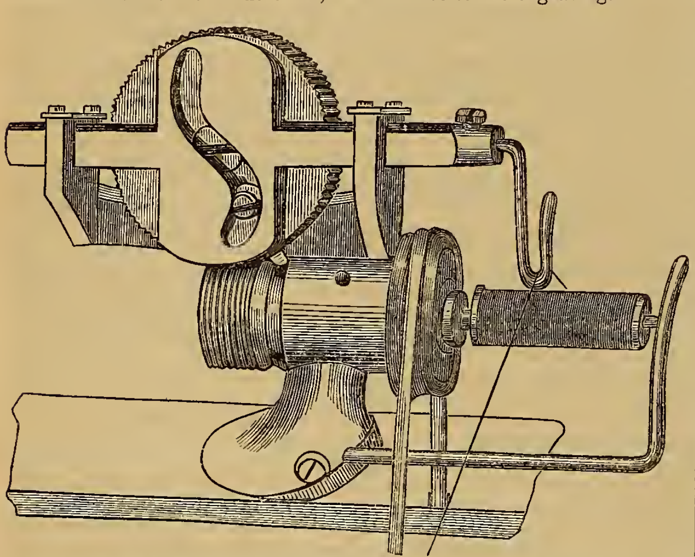
Passing from the coal to the iron trade, the president said: The Institute owes its origin to the iron trade, and ever since the first meeting, those connected with the South Wales iron trade have strenuously supported it, and contributed papers from time to time upon the various improvements effected in blast furnaces, manufacture of coke, manufacture of steel, selection and treatment of coal for blast furnaces, regenerative furnaces, blooming rolls, &c., &c., but we have had no paper upon the all important matter of the economising of fuel in the manufacture of iron, and on the best means to be devised for the purpose of extending the use of our native ironstone, the consumption of which has for some years past been gradually falling off, while the quantity of iron made in the district has been increasing. Very great improvements have been and are being made at some of our iron works in increased makes of iron, in reducing the quantity of large coal, and in consuming small coal in the manufacture of iron, but many are still going on upon the old system. As an instance of what has been done at an iron works in this district, I may mention that they now make six times the quantity of iron per furnace that they did twenty years ago; and by a proper admixture of coal and coke, utilisation of gases, hot blast, &c., the quantity of fuel per ton of pig iron is less than one-half what it was then. In puddling furnaces again, by the introduction of the blast with small coal, the fuel has been reduced 12 per cent. in quantity, while only a third or fourth of large coal is used. While the manufacture of iron has made great strides in this district in the last twenty years, there is still more to be done, in the substitution of machinery for manual labour, and the utilisation of all the resources at our command, to enable this district to keep pace with other places having the advantage over us in respect to the important item of iron ore. As will be seen by the able paper contributed by Mr. E. Williams, our friends in the North are far out-stripping us in the improvements in their furnaces and the economising of fuel, and it is our duty to benefit by the experiments they have made, and avail ourselves of the improvements, so far as they apply to the ores at our command. As for fuel we need not fear our best coal yielding coke equal to Durham. There is therefore no reason why we may not realise equally good results. The cost at which our argillaceous ironstone is obtained, the low percentage of iron contained, and the difficulty of smelting it, are serious obstacles in attempting to use it in any large proportion; but looking at the immense quantities in which this district abounds, a great portion of which can be wrought by open patches and levels, and some of it with coals, we surely ought to take the matter into consideration, with the view of ascertaining what means, if any, in improvements in furnaces, &c., can be devised for continuing, if not extending its consumption in a profitable manner—instead of as at present, gradually reducing it—and I would invite the serious attention of the Institute to this matter. Besides the argillaceous ironstone, we have in the basin several deposits of hematite iron ore, lying above, and in, the limestone and in the shales of the old red sandstone which have hardly been fully developed, and do not seem to have been brought before the notice of this Institute. It is not impossible that a paper giving a full description of the iron ore mines already at work might lead to further trials being made in ore-bearing ground, and discoveries made whereby our works may be very much less dependent on the importation of foreign ores.

There is only one other matter which I will trouble you upon—that is to suggest that important questions, requiring much time and consideration in experiments, the getting up of information and plans, &c., should be placed in the hands of committees of members of the Institute in the same way as is practised in the North, and where, I am informed, it has proved highly satisfactory; and also that a list of subjects should be drawn up by the Council of the Institute every year, upon which they should invite papers; and that premiums of books or medals should be awarded to the writers of the best papers. This works remarkably well in the Institution of Civil Engineers, and I believe it would tend to materially improve the position as well as the increase the usefulness of our Institute. There are many other matters having an important bearing upon the mineral wealth and manufactures of our district, which I cannot at present refer to, having already far exceeded the bounds of a reasonable address. I will therefore close by asking your serious consideration to the several points worthy of attention; and if, during my term of office, we shall be able to do something towards reducing the enormous losses caused by the present mode of working and treating our minerals, and secure their being worked and used in a more economical manner with the least possible risk of life, I shall not have occupied your time in vain, and this Institute will have conferred an additional boon upon our district, and fully realised some of its objects.

AUTOMATIC BOBBIN WINDER FOR SEWING MACHINES.

One of the chief arguments nsed by the chain-stitch sewing machine interest against the double-thread machines is the trouble experienced in winding bobbins. The chain-stitch machines using thread direct from the spool do not involve this difficulty. The object of the invention shown in the accompanying illnstration is to provide an automatic bobbin winder that shall fill the bobbins while the machine is in operation, so that all the operator has to do when a new bobbin is required is to place it in the shnttle. Each bobbin is similar to all the others when filled and the apparatus may be so adjusted that long or short bobbins may be wound with equal facility and certainty.

The simplicity of this ingenious addition to the sewing machine is snch that it will be at once nnderstood, on reference to the engraving.



The stock of the bobbin winder is screwed to the clothplate of the machine. The bobbin is placed upon a spindle, the shaft of which has upon it a small grooved pulley which is driven by the band from the fly wheel. A worm on this spindle works in a toothed wheel. This wheel has projecting from its side a pin which works in a cam attached to the thread guide. This arrangement gives a traverse motion to the thread guide from end to end of the bobbin as the spindle revolves, thus distributing the thread evenly along its surface, and filling it much more uniformly than can be done by hand.

The cam slot is S-shaped, and the pin working therein is adjustable to and from the centre of the toothed wheel, by which the traverse motion is shortened or lengthened to wind bobbins of different lengths.

These bobbin winders are made in different styles for the various shnttle machines in use, and appear to be very desirable and useful additions to such machines.

OLD BLACKFRIARS BRIDGE.

In pulling down the Old Blackfriars Bridge, it was expected that the foundation stone and the relics deposited therein, would have been discovered. In spite of a diligent search made for that purpose, nothing whatever, could be found, and all hope of recovering these memorials had vanished. It happened, however, that it lately became necessary in consequence of the flooding of the basements of the houses in Bridge-street, to make considerable excavations for the improvement of the outlet of the river Fleet, and during the progress of that work these interesting relics have at last been discovered. The letter forwarded by Mr. Cook, the foreman to Mr. Webster the eontractor for the works is as follows:—

"Northern Thames Embankment Office,
"Whitefriars, E.C., Oct. 5, 1870.

"Sir,—Herewith I beg to forward to you a plan and sections of the foundation and memorial stones of the old Blackfriars Bridge, which were discovered on the 30th nlt. and 1st inst., at a depth of 30ft. under the roadway, in the large open cutting which is now being excavated in Bridge-street by Mr. William Webster, the contractor under your Board for the constrnction of the overflow outlet of the Fleet and the penstocks of the low level sewer. The depth of our excavations being 8ft. lower than the foundations of the old bridge, a portion of the masonry had to be cut away. This having to be done with care, and while personally attending to the removal of the upper 2ft. 6in. course, I was happy to discover iu the bottom bed of one of the stones a cavity containing an oak case, in which was deposited the metallic plate, which has been duly forwarded to the offices of the Board at Spring-gardens, and which records that the fonndation-stone of the bridge was laid on the last day of October, 1760, by Sir Thomas Chitty, the Lord Mayor, Robert Mylne being the architect. The foundation stone I found to be one of the lower 2ft. 3in. course, which is bedded upon three layers of pine planks bolted together by oak trenails. The cavity in this stone was filled np with mortar flush to the top bed; Having tooled out the mortar, the beautiful silver medallion, which has already been sent to the Board, was found encased in lead. Below this was a further layer of mortar, and underneath that, without any protection, whatever, I found the following coins; One guinea of George II, bearing date 1759; one half-crown, 1759; one crown piece, 1750; one shilling, date illegible; two sixpenny pieces, 1758; 31 half-pence of George II, of various dates from 1734 to 1750; and one farthing of George II, dated 1741; which have also already been forwarded by Mr. Webster to the offices of the Board.

"Yours obediently,
"Benjamin Cooke, Manager.

"To John Pollard, Esq., Clerk of the Metropolitan Board of Works, Spring-gardens."

SUBMARINE WARFARE.

In Sheerness harbour, on the 8th ult., an interesting experiment was made with a new kind of torpedo, which is the joint invention, as we are informed, of a Mr. Wightman and an Austrian gentlemau. It is a "submarine flight torpedo," the construction and principle of which have hitherto been kept a profound secret, and in a very great degree still remain so. The experiment under notice was made by direction of the Lords of the Admiralty, and although the torpedo had been lying in one of the store-houses in Sheerness Dockyard for some days, no one, except those employed by the inventors, has been permitted to inspect it. From what we can glean, however, it appears that the torpedo itself is of a fish-shaped construction, of zinc, having a revolving "tail" at one and. It is necessary that a ship intended to discharge the torpedo should be fitted with an apparatus (also newly invented) for the purpose of compressing air within a sort of cylinder, and to this is fixed a long tube for the reception of the torpedo. This tube, which is similar to a rocket tnbe, is carried from the interior of the ship, through a hole in the bows eight or ten feet below the surface of the water. The orifice of the tube next the water is covered with a cap, to which a line is attached and carried up to the forecastle for the purpose of removing it when all is ready to discharge the torpedo, the latter being filled with gun cotton and other detonating and powerfully explosive substances. The cylinder being fill with air, the torpedo is placed in the tube in the same manner as a congreve rocket. The vessel is then steered to within a suitable distance of the vessel to be destroyed, and the cap removed by means of the line above mentioned. The compressed air is then forced into the tnbe, and the torpedo is launched with a sufficient submarine momentum to strike aud destroy any ship within a range of from 100 to 1,800 yards. For the experiment on the 8th ult, Her Majesty's steam sloop of war *Oberon* had been expressly fitted with all the apparatus above described. She was steered (so as to avoid danger to other craft in the harbour) to within about 200 yards of *L'Aigle*, an old wooden frigate of great strength, and lately used as a coal hulk, which had been lent by the Admiralty for the purpose. This vessel was moored head and stern on what is called the west shore of the Isle of Grain, in a sufficient depth of water to cause the effect of the explosion of the torpedo to be seen by the ship sinking some 10 or 12ft., the object in view being that the destruction of the ship's bottom might be visible at low tide, and also that the vessel might be temporarily repaired so as to be floated for further probable experiments. About 1 o'clock on the 8th ult, the tide being nearly flood, the *Oberon* was placed bows on to *L'Aigle*, and a striped flag hoisted on board. Shortly afterward this flag was lowered as a signal that the torpedo had been sent on its errand of destruction. Expectation was now on tip-toe, for it had been anticipated that the explosion would be instantaneous, but it was not so; and, after a few seconds had elapsed, whispers began to be heard that the experiment was a failure, or that the torpedo had taken a wrong direction. In about 30 seconds, however, from the lowering of the flag, an explosion occurred, under the counter of *L'Aigle*, and a mountain of water, blackened with coal dust from the refuse in the hulk thrown up. The stern of the ship rose bodily with it, and now was heard a report resembling the dull boom of a heavy piece of ordnance heard at the distance of a mile or so. *L'Aigle*, immediately on falling back into the water, sank by the stern until she took the bottom, but had there been sufficient depth of water she would have totally disappeared. As it was, the ship speedily filled with water from stem to stern, and in about a minute from the time of the explosion had sunk her entire length, and lay on the bottom, with only about seven or eight feet of her upper works and bulwarks above the surface. She has not yet been officially examined, but is is believed the hole made in her counter and under her bilge must be of enormous dimensions, from her going down so quickly.

SHIPBUILDING ON THE CLYDE.

We recently gave an estimate of the amount of shipbuilding work that had been accomplished on the Clyde during the three quarters ending 30th September. The total tonnage launched during that time was 137,000 tons, 4,000 less than during the same period of previous year, but 18,000 tons more than during the three quarters in 1868. The amount of work actually on the stocks at present, including vessels of which the keels have been laid to those about ready for launching is 84 vessels, of an aggregate tonnage of about 80,000 tons. The following is the number of vessels in the various yards on the Clyde, in each district:—In the yard of Messrs. Barclay, Curle, and Co., Messrs. J. and G. Thomson, C. Connal and Co., A Stephen and Sons, R, Napier and Sons, London and Glasgow Engineering and Ironshipbuilding Co., Dobbie and Co., and A and J. Inglis—20 vessels. In Messrs. Tod and M'Gregor's, John Elder and Co.'s, A. Stephen and Son's (new yard)—14 vessels. At Whiteinch—Messrs Barclay, Curle, and Co., Wingate and Co., J. G. Lawrio, and Aitken, and Mansel, have 9 vessels. At Renfrew—Messrs Wm. Simmonds and Co., and Henderson, Coulborn, and Co., have 8 vessels. At Port Glasgow—Messrs Blackwood and Gordon, R. Duncan and Co., J. Reid and Co., and M'Culloch, Patterson and Co., have 8 vessels; and at Greenock Messrs Scott and Co., Steele and Co., and Caird and Co., have 10 vessels. There are also building at Dumbarton by Messrs Denny and and Brothers and M'Millan and Sons, at Rutherglen by Mr. T. B. Seath, and at Maryhill by Messrs J. and R. Swan, 15 vessels. In two of the yards there are no fewer than 17 vessels on the stocks—Mr. Elder having nine and Messrs Caird and Co., 8 vessels in various stages of completion. In addition to the new vessels there are several steamers being lengthened and receiving new engines and boilers and general overhauls.

AMERICAN STEEL MANUFACTURES.

A special correspondent of the *New York Times* is supplying to that journal an account of the steel manufacturers of the United States. He has visited the Pennsylvania Steel Works, located on the east bank of the Susquehanna, about three miles south of Harrisburg. This establishment was built in 1866-67 by Mr. Holley, now of the Troy Bessemer Steel Works, and cost about a million dollars. A description is given of the plant and of the process of making steel rails, and the writer then proceeds in the following strain:—"The Pennsylvania Steel Works have been uniformly successful with their product, and make a metal of absolutely uniform quality. I regret to say that they are content to use three-fourths foreign iron, and only one-fourth American. It is true that very little Bessemer pig is made in this country, and as a disinterested party, I sincerely hope that the Bessemer steel-makers will be compelled to adopt measures to produce domestic irons for their own consumption. In truth, blast furnaces are as much a part of a Bessemer plant as a rolling mill, and no company ought to undertake to manufacture the steel unless they are able and willing to build them. It is impossible to doubt that suitable ones may be found in many localities, and, with patience, enterprise, and a judicious outlay of capital, may certainly be smelted with profit to the steelmaker. English irons used at Troy and Harrisburg cost over 40 dollars per ton, while domestic irons used at Cleveland cost 35 dollars. But it will require a better blast furnace practice than that which is now in vogue throughout Pennsylvania, and which is simply horrible in a majority of cases. The cost of making Bessemer rails is nearly 100 dollars per ton, and as that is now the market price the margin of profit is small. The retrenchment must be chiefly in the cost of pig-iron. It will require vast research, innumerable analyses, and the most thoroughly scientific and skilful blast-furnace practice to effect a reduction of the cost; but in a State so rich as Pennsylvania in mineral wealth there certainly seems to be no sufficient reason why the effort should not be successful. The annual product of the Pennsylvania works may be practically estimated at 15,000 tons of rails, all of which are consumed by the Pennsylvania Railroad Company.

THE LOSS OF THE "CAPTAIN."

Since the notice in THE ARTIZAN for last month of the foundering of this magnificent vessel, the court-martial has been completed, and the verdict which we give below appears to be as comprehensive as could be expected, and entirely in accordance with the evidence. As we anticipated, the evidence went to show that the centre of gravity, although not above the line of flotation during the trial for stability, nevertheless, was dangerously high. According to the evidence upon this point, when the ship was inclined, to practically ascertain her centre of gravity, it was found to be situated at 2·9ft. below load water line, the vessel at that time drawing 25ft. ½in. of water. We have, unfortunately, no exact data of the draught of water of the vessel at the time when she foundered, but, judging from the length of her cruise, she probably drew considerably less water than at this trial, and, consequently her centre of gravity would be proportionately nearer the load water line, making her still less able to stand up against the wind.

Now that the true cause has been officially pronounced, we trust, that the panic occasioned by this terrible disaster, will not compel the government to desist from building low free-board turret vessels. There is no difficulty whatever, in building a vessel of this description with a sufficiently low centre of gravity, and with a reasonably steady platform. Whether it is advisable to rig such ships with heavy spars—or even with any spars at all, is a different question. In our opinion, the disadvantage incurred by using such ships as sailing vessels, more than counterbalances the saving in fuel; as it involves extra hands, and therefore, the finding of extra accommodation—a very difficult problem in this class of vessel; and also, absolutely prevents an all round fire, which is supposed to be the one distinguishing merit of the system.

The following is the verdict returned by the Naval Court appointed to inquire into the causes which led to the loss of H.M.S. *Captain*:—"The court having heard the statements of Mr. May relative thereto, and taken his evidence and that of the remaining survivors, and the other evidence they deem necessary, and having deliberately weighed and considered the whole of the evidence before them, do find that H.M.S. *Captain* was capsized on the morning of the 7th of September, 1870, by pressure of sail assisted by the heave of the sea, and that the sail carried at the time of her loss (regard being had to the force of the wind and the state of the sea) was insufficient to have endangered a ship endued with a proper amount of stability. The court further find that no blame is attributable to Mr. James May, gunner of the second class, and the surviving petty officers and men of H.M.S. *Captain* for her loss, and do, therefore, fully acquit them of all blame in respect of it, and the said Mr. James May, gunner of the second class, and the surviving petty officers and men of H.M.S. *Captain* are hereby fully acquitted accordingly.

"The Court, before separating, find it their duty to record the conviction they entertain that the *Captain* was built in deference to public opinion, expressed in Parliament and through other channels, and in opposition to the views and opinions of the Controller of the Navy and his department, and that the evidence all tends to show that they generally disapproved of her construction. It further appearing in evidence that before the *Captain* was received from her contractors, a grave departure from her original design had been committed, whereby her draught of water was increased about 2ft., and her freeboard was diminished to a corresponding extent, and that her stability proved to be dangerously small, accompanied with an area of sail under these circumstances excessive. The Court deeply regret that if these facts were duly known and appreciated, they were not communicated to the officer in command of the ship, or that if otherwise the ship was allowed to be employed in the ordinary service of the fleet before they had been sufficiently ascertained by calculation or experiment."

GUIANA EXHIBITION.

The opening of this exhibition of natural and industrial products, &c., is extended to Wednesday, the 8th of February, 1871, and it is desired, in making that change known, to invite the especial attention of the artists of this country to the opportunity which will be thereby afforded to them, of bringing their productions under observation in a hitherto untried and novel field, with a reasonable prospect of practical results in the shape of sales. The artist contributors will be guaranteed against all risk of loss or expense, and will have the chance of sharing in the distribution of honorary marks, medals of gold, silver, or bronze, with certificates of honourable mention, which it is the intention of the committee of correspondence to award to competitors. The scheme provides for the reception in London, storage, packing, freight, and insurance on the voyage out and home, and whilst in the colony, of all such contributions with a guarantee for the safe return and delivery to the owners of all such as may remain unsold, and the payment of the prices in all cases where sales may have been effected on the terms named by the artist. All articles will be returned after a comparatively brief interval, it being fully intended that such as remain unsold should be shipped from the colony by the Royal Mail steamer leaving Georgetown on the 8th March, so as to be in London on the 29th of that month. Any further particulars desired will be furnished on application to Mr. McLean, of the Haymarket, who has undertaken to assist the committee in London. The committee, Messrs. E. G. Barr and W. Walker, will also be happy to receive and answer any inquiries addressed to their offices, 36, Mark-lane, E.C.

OBITUARY.

THE LATE MR. JOHN BRAITHWAITE, C.E.

John Braithwaite, C.E., one of our oldest engineers and whose name is identified with many novelties in engineering, died at midnight on the 1st, ult., the cause being apoplexy. From the earliest period in railway history, Mr. Braithwaite had been engaged in the promotion and construction of lines, both in England and on the Continent. In laying out the Eastern Counties Railway—of which he was engineer-in-chief—Mr. Braithwaite adopted a gauge of 5ft. which, however, was afterwards altered to the ordinary 4ft. 8½in. gauge. Mr. Braithwaite took an active part in the battle of the gauges, which was fought some twenty years since. He was a supporter of the narrow gauge, and has of late years expressed himself in favour of the adoption of still narrower gauges than are now generally employed. In 1829, Mr. Braithwaite in conjunction with Mr. Ericsson, designed the "Novelty" locomotive engine, which was tried on October 10th in that year, against the "Rocket" engine of Mr. R. Stephenson, and the "Sans Pareil" of Mr. T. Hackworth. To Mr. Braithwaite belongs the credit of having made the first steam fire-engine, so far back as the year 1829, in London, in conjunction also with Mr. Ericsson. Four more of these engines were subsequently constructed by these gentlemen, all being eminently successful; yet, so strong was the prejudice which was brought to bear against them, that, from 1832 until 1862, no more were made in this country. Mr. Braithwaite was also well known in connection with most of our large breweries, and for various improvements which he effected in their mechanical arrangements. He was especially engaged in sinking wells in connection with these establishments, having sunk a large number, some of very great depth, for numerous breweries. Mr. Braithwaite was elected a member of the Institution of Civil Engineers on Febrnary, 13, 1838, and was elected a member of the Society of Arts in 1819.

THE LATE PROFESSOR MILLER.

We deeply regret to have to announce the death of our old teacher William Allen Miller, M.D., F.R.S., &c., Professor of Chemistry at King's College, London. He died suddenly in almost the prime of life, on the 30th of September, while engaged in taking part in the proceedings of the British Association. Dr. Miller was born at Ipswich on the 17th of December, 1817, and in his twenty-fourth year he became assistant to the late Mr. Daniell, professor of chemistry in King's College, London. In 1844, he co-operated with his master in the publication of a paper on the "Electrolysis of Secondary Compounds." In the following year he was elected a Fellow of the Royal Society, and upon the demise of Mr. Daniell was elected to the chair of chemistry in King's College. His chief work at this time was his paper on the "Spectra of certain Vapours," published in 1845. In 1849, he again came before the scientific world with a paper on the "Atomic Volumes of Organic Liquids," Dr. Miller held the posts of treasurer of the Royal Society, president and afterwards vice-president of the Chemical Society, and assayer to the Royal Mint, besides being a member of the Science Commission. His later contributions to the scientific periodicals were, a paper on "Transparency," in the *Journal of the Chemical Society*, "Some Analyses of Gutta Percha, and "A Treatise on Potable Water." In conjunction with Mr. Huggins he investigated the spectra of the fixed stars. He is known to the educational world by his voluminous and widely-popular "Treatise on Chemistry," in three parts, which originally appeared from 1855 to 1857, and which has already gone through several editions. Several candidates are already in the field for the professorship he leaves vacant.

Mr. William Alexander Provis, who was elected a member of the Institution of Civil Engineers, on the 6th of April, 1819, and whose decease occurred on the 29th September, has bequeathed the munificent sum of £500, to "The Benevolent Fund of The Institution of Civil Engineers."

NOTES AND NOVELTIES.

MISCELLANEOUS.

By a law approved July 8th, 1870, foreign trade marks and designs are protected in the United States.

There has lately been exhibited at the offices of the Silk Supply Association a specimen of South African silk from the Cape, which has been pronounced of high-class quality.

A steam-paving machine was recently introduced in Paris, and made use of by the municipality for the repair of the streets of that city. This machine consists of a small steam-engine on wheels, drawn by one horse, to the rear of which is attached the "pavior," which is forced upon the ground by a blow from the piston, and slides on a bar some six feet long, and can thus be directed by the driver to any stone which requires forcing home. The machine was lately at work in the Rue de Grenelle, and was considered a success

Experiments were made on Friday, September 30th, at the mouth of the Mersey, with Rogers' life-saving apparatus. When thrown to a vessel in distress the projectile used is a cone projected from a mortar; when thrown for the purpose of getting a purchase to haul a boat out from the beach, the projectile has a folding anchor at the head, the arms of which expand and bite the ground directly there is a pull upon their centre by the line through the hollow of the projectile carried by the latter when shot from the projecting mortar. The experiments were quite successful, and, as the apparatus is simple and inexpensive, it will no doubt be taken up by shipowners; and its greater range and accuracy will possibly cause it in time to supersede the rocket apparatus at the coastguard stations.

The following has been forwarded to the secretary of the Royal Agricultural Society of England, from the Austro-Hungarian ambassador, with a request to give it publicity:—"The Royal Hungarian Ministry for Agriculture, Commerce, and Industry, proposes to award two prizes, of 100 ducats and 50 ducats, for the invention of a hemp mowing or cutting machine, under the following conditions—1. Mowing machines which cut the hemp as short as possible over the soil may compete, as well as plough-like instruments which cut it under the soil. 2. No models will be admitted. 3. The competing machines or instruments will be submitted to a trial on an ordinary hemp field, at a place and date to be fixed hereafter. The results will be examined and the prizes awarded by a committee composed of agriculturists and engineers. 4. The first prize can only be awarded to a thoroughly well working and efficient machine or instrument. 5. The machines which obtain the prizes remain the property of the competitors. 6. The applications for the competition are to be made till June 1. 1871, to the Royal Hungarian Ministry of Agriculture, Industry, and Commerce at Pesth, to which also all inquiries relating to the details of the trial are to be addressed.—Pesth, August 13, 1870."

NAVAL ENGINEERING.

The Brazilian Government has decided upon adding some formidable ironclads to its navy. Two of these ironclads are to be built in England, under the superintendence of Captain Silveira de Motta.

MILITARY ENGINEERING.

The following appendix to an Army Circular relating to muzzle-loading guns has recently been issued:—"All service rifled muzzle-loading guns up to 9in. calibre inclusive may be fired without restriction as to the number of rounds, the service ability or otherwise of the guns being ascertained from the results of examinations. With 10in. rifled muzzle-loading guns 500 rounds may be fired, of which 250 may be with battering charges, after which the guns will be examined at Woolwich, or by skilled persons sent from the Royal Gun Factories. With 12in. rifled muzzle-loading guns 250 rounds may be fired, of which 100 may be with battering charges, after which the guns will be examined as above."

TELEGRAPHIC ENGINEERING.

A line of telegraph from Auckland, New Zealand, to the Thames has been completed, and is now in full working. From the South the wires have advanced to within about seventy miles of Cambridge, to which place wires from Auckland already reach. It will not, therefore, be long before Auckland is in direct telegraphic communication with every part of the north island of New Zealand.

STEAMSHIPPING.

Messrs. Wm. Denny and Brothers Dumbarton, have contracted to supply the Peninsular and Oriental Steam Navigation Company with a screw steamship of 3,000 tons and 550 horse-power. The ship is to be fitted up in the usual style of the company's fleet; and the machinery, by Messrs. Denny and Co., is to be on the compound principle. Messrs. Morton, Wyld and Co., of the Woodyard, have contracted to build an iron screw steamer of 1,000 tons for a Liverpool house.

LAUNCHES.

There was launched from the building-yard of Messrs. John Duthie and Sons, on the 18th ult., a three-masted schooner, named the *Mary Blair*. She is 321·76 tons register, by 146ft. in length, 27ft. breadth of beam, and 14½ft. in depth. She is to trade between Sydney and China, and was built to the order of Messrs. James Owen and Co., London.

On the 25th September there was launched from the shipbuilding yard of Messrs. Aitken and Mansell. Whiteinch, a smart screw vessel of 500 tons register, for Leith owners. She was named the *Hazard* by Mrs. Menzies, of Partick, and is to be fitted with engines of 90 horse-power nominal.

Messrs. R. Duncan and Co., Port Glasgow, launched on the 27th September a handsome steamer, named the *Duke of Leinster*, for the Dublin and Glasgow Steam Packet Company, of the following dimensions:—250ft. long; 29ft. in breadth; depth, 15ft.; 1,040 tons builders' measurement; 700 tons register tonnage. The steamer was, immediately after the launch, towed to Greenock, where Messrs. Rankin and Blackmore will supply her with oscillating engines of 500 horse-power.

The fine new iron sailing barque *Virginia*, 885 tons, was launched on the 27th September by Messrs. Alexander Stephen and Sons, from their works at Kelvinhaugh. The *Virginia* has been constructed to the highest class in Bureau Veritas, and is to be employed in the American trade.

There was launched, on the 26th September. from the dockyard of Messrs. Archd. M'Millan and Son, Dumbarton, a handsome screw steamer, built to the order of the Liverpool and Mississippi Steamship Company. On leaving the ways she was named the *Crescent City* by the wife of Mr. Thos. Main. The vessel has been built to class 100A being the highest class at Lloyd's, and her dimensions are 325 by 35 by 27·6. The engines, which are of 220 horse-power, have been constructed by Messrs. John and James Thomson, Glasgow. They are on the compound principle, and embrace all the latest improvements.

Mr. J. G. Lawrie launched on the 21st September at Whiteinch a yacht of 60 tons, for Mr. Robert Macfie, of Airds. The yacht, on leaving the ways, was named *Viking*, by Miss Allan, of Park-terrace.

ON the 19th ult. Messrs. Barclay, Curle, and Co., launched from their yard at Whiteinch a screw steamer named the *City of Oxford*, of 2,000 tons, for Messrs. G. Smith and Sons, Glasgow. The *City of Oxford* is pioneer of a fleet of steamers being built for Messrs. Smith and Sons for the Clyde and East India trade, *viâ* the Suez Canal.

THE fine new three-decker iron screw steamer *Shiraz* was launched on the 19th ult., by Messrs. Alex. Stephen and Sons, from one of their shipbuilding sheds at Kelvinhaugh. The *Shiraz* is 1,130 tons, AA1 at Lloyd's, and is owned by Messrs. Gray, Dawes, and Co., London. Her engines have been furnished by Messrs. James Howden and Co., and she is to be employed in the India coasting trade.

MESSRS. ROBERT DUNCAN AND CO. lately launched from their shipbuilding yard, Port Glasgow, a screw steamer named the *Alexandria*, of 1,550 tons, for Mr. Robert Little, Greenock, and intended for the Anchor Line Atlantic service.

THE London and Glasgow Engineering and Iron Shipbuilding Company launched from their yard at Govan, on the 16th September, a screw steamer of 1,500 tons, and of the following dimensions:—Length, 252ft.; breadth, 32ft.; depth of hold, 16ft. She is built to the order of Messrs. J. A. Dunkerley and Co., Hull, and is intended for the India and China trade, *via* the Suez Canal.

TRIAL TRIPS.

THE *Briton*, 10 guns, screw corvette, has been ordered by the Lords of the Admiralty to be prepared for further trial with and without Cowper's newly patented "steam reheater," the former trials not being considered wholly satisfactory.

THE *Audacious*, 14, Captain D. Spain, in charge of Captain Fellowes and staff, of the Steam Reserve, with Captain Marsh, the Queen's Harbour Master, Mr. Bardin, C.B., Inspector of Machinery, and other officials on board, proceeded to the offing on the 17th ult., for the purpose of testing her speed on the measured mile. Like the *Vanguard* (tried on the 15th ult.), this ship has lately had the space between her double bottom filled with water to the extent of 242 tons, which has increased her draught 2ft., but gives her great stability, for with the helm put over one and a-half turns, instead of heeling seven or eight degrees, as before, the ship was perfectly upright, although she had the wind strong on her beam. The draught forward was 22ft. 2in.; aft, 22ft. 10in.; the barometer, 29·70; thermometer, 57; wind, N.W.; force, 5. Two runs were made on the mile, with the following results:—The first to the eastward, in 4min. 33sec., equal to 13·187 knots; the second, to the westward, in 5min. 10sec., equal to 11·613 knots, giving a mean speed at full power of 12·4 knots, with mean revolutions 70·005 per minute; mean steam, 31lb.; mean vacuum, 21·5in. The wind and sea at this time having greatly increased, the further trial was postponed for more favourable weather.

RAILWAYS.

THE line from Delhi to Lahore is expected to be completed and in working order before the end of the year.

THE San Francisco *Call* says:—"The people of Austin, Nevada, are seriously discussing the project of constructing a branch line of railway from that place to some point on the Central Pacific, probably Battle Mountain. The distance is but ninety miles, and the Central Pacific Company is said to be ready to construct and operate the road, if the people will subscribe stock sufficient to grade the way."

THE Paisley Town Council have been discussing the desirability of having a tram railway between Glasgow and Johnstone, and have concluded by proposing that notice should be given, in terms of the statute, of their intention to apply, as the local authority for part of the line, for permission to construct the same.

ON the 5th ult., another portion of the road tramway system now being constructed in the south of London, extending from the Horns Tavern, Kennington, to Hercules-buildings, near Westminster-bridge, was opened for public traffic. By this extension the public will have the advantage of direct tramway communication from Brixton to within a short distance of Westminster-bridge.

THE engineer, Mr. Rosetti, appointed by the Government of the Argentine Republic to survey the passes of the Andes with reference to the construction of a railroad between that republic and Chili, reports that the most eligible pass, under the circumstances, is the Planchon or Teno, and he indicates the route from Buenos Ayes to the Teno station on the Santiago and Curico Railway. The elevation is 3,300 metres. The most difficult part is that in the Vargara ravine, where there is a difference of level of 730 metres in a distance of ten kilometres, which gives a grade of 70 in 1,000. The length of the road by the line indicated will be 1,651 kilometres, and its cost is calculated at 26,000,000 dols. for the Argentine division, and 6,000,000 dols. for the Chilian, and the time requisite to complete the work four years.

THE weight of the engines to be used upon the Quebec and Fosford Wooden Railway, which has been opened last month, is twenty-one tons; they will have four driving wheels 42in. in diameter. The City Passenger Railway Company of Montreal has declared a dividend for the six months ending September 30, 1870, of six per cent. upon the capital stock of the company, with a bonus of two per cent.

THE Sutlej Bridge of the Sind, Punjab, and Delhi Railway Company was opened on the 15th ult. by the Maharajah of Puttealah, with great state, celebrating the establishment of an unbroken railway communication between Lahore, Calcutta, and Bombay.

THERE are in the United States, says the *Philadelphia Ledger*, 48,000 miles of railway which it is necessary to relay with steel rails. It takes 100 tons of rail to lay a mile of road. The estimation of 200,000 tons would only relay 2,000 miles annually. If steel rails were admitted free their consumption here would be enormous, and the advantage to railway companies correspondingly great. Dear rails means dear transportation, with large profits to the manufacturer of the domestic article. The two interests involved are in a great measure sectional. The great West wants cheap railways, that it may, by cheap transportation, put the product of its labour and enterprise into the markets of the world at the smallest possible cost, whilst those capitalists, principally at the East, engaged in making steel rails, desire exclusively to themselves the home market, for a comparatively new article, at paying profits.

BELGIUM exported in the first six months of this year 19,566 tons of rail to Russia; to the Zollverein, 18,311 tons; to Turkey, 12,356 tons; to France, 4,109 tons; to Italy, 3,832 tons; to the United States, 2,999 tons; to Sweden, 1,700 tons; and to Spain, 1,657 tons

MINES, METALLURGY, ETC.

A RICH silver mine has been discovered near Huamantaga, in Peru, and measures are, taken for working it.

THE production of Lake Superior copper ore this year is estimated at one million tons which is twice as much as was produced in the entire United States in 1863.

APPLIED CHEMISTRY.

THE Abbé Moigno has recorded that when picric acid is introduced into a vessel containing ozone a violent detonation instantaneously takes place, a new proof of the danger attending experiments with nitrogenous compounds containing nitrogen only loosely bound.

LATEST PRICES IN THE LONDON METAL MARKET.

	From			To		
	£	s.	d.	£	s.	d.
COPPER.						
Best selected, per ton	70	0	0	,,	,,	,,
Tough cake and tile do.	68	0	0	,,	,,	,,
Sheathing and sheets do.	71	0	0	73	0	0
Bolts do.	73	0	0			
Bottoms do.	73	0	0	75	0	0
Old (exchange) do.	60	0	0	,,	,,	,,
Burra Burra do.	69	0	0	70	0	0
Wire, per lb.	0	0	$9\frac{1}{2}$	,,	,,	,,
Tubes do.	0	0	$10\frac{1}{2}$	,,	,,	,,
BRASS.						
Sheets, per lb.	0	0	$7\frac{1}{2}$	,,	,,	,,
Wire do.	0	0	7	0	0	$7\frac{1}{4}$
Tubes do.	0	0	$9\frac{1}{2}$	0	0	$10\frac{1}{2}$
Yellow metal sheath do.	0	0	$6\frac{1}{4}$	0	0	7
Sheets do.	0	0	6	0	0	$6\frac{1}{8}$
SPELTER.						
Foreign on the spot, per ton.	17	0	0	17	10	0
Do. to arrive.	17	5	0	,,	,,	,,
ZINC.						
In sheets, per ton	22	0	0	23	0	0
TIN.						
English blocks, per ton.	129	0	0	130	0	0
Do. bars (in barrels) do.	130	0	0	131	0	0
Do. refined do.	133	0	0	,,	,,	,,
Banca do.	127	0	0	128	0	0
Straits do.	127	0	0	128	0	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	7	0	1	9	0
IX. do. 1st quality do.	1	13	0	1	15	0
IC. do. 2nd quality do.	1	5	0	1	6	0
IX. do. 2nd quality do.	1	11	6	1	12	0
IC. Coke do.	1	2	0	1	3	6
IX. do. do.	1	8	0	1	9	6
Canada plates, per ton	13	10	0	14	10	0
Do. at works do.	13	0	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	5	0	,,	,,	,,
Do. to arrive do.	7	5	0	,,	,,	,,
Nail rods do.	7	10	0	,,	,,	,,
Do. Stafford in London do.	7	15	0	8	0	0
Bars do. do.	8	2	6	9	0	0
Hoops do. do.	8	15	0	9	0	0
Sheets, single, do.	9	10	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	0
Bars, common, do.	6	10	0	6	12	6
Do. mrch. Tyne or Tees do.	6	10	0	,,	,,	,,
Do. railway, in Wales, do.	6	0	0	6	5	0
Do. Swedish in London do.	9	10	0	9	12	6
To arrive do.	9	15	0	,,	,,	,,
Pig No. 1 in Clyde do.	2	12	0	3	0	0
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. No. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	17	0	6	0	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pig in London do.	6	5	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	12	10	0	13	0	0
Do. (hammered) do.	13	0	0	14	0	0
Do. in faggots do.	15	0	0	,,	,,	,,
English spring do.	17	0	0	,,	,,	,,
QUICKSILVER, per bottle	8	8	0	,,	,,	,,
LEAD.						
English pig, common, per ton	18	0	0	,,	,,	,,
Ditto L.B. do.	18	0	0	18	5	0
Do. W.B. do.	17	10	0	20	0	0
Do. sheet, do.	19	0	0	,,	,,	,,
Do. red lead do.	20	10	0	,,	,,	,,
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	21	10	0	,,	,,	,,
Spanish do.	17	10	0	,,	,,	,,

* At the works 1s. to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite Information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated September 27th, 1870.

2572 J. R. Taher—Twisting
2573 S. Bennett—Hot water
2574 O. Nilson—Fire-arms

Dated September 28th, 1870.

2575 E. Lord—Card rollers, &c.
2576 O. Nilson—Printing presses
2577 J. I. Bengough—Air-tight vessels
2578 W. R. Lake—Electro-magnets
2579 A. McKenzie—Carriages, &c.
2580 J. E. Bingham—Oxidization or tarnishing silver surfaces
2581 T. Moore and C. A. Head—Raising and lowering sacks
2582 S. Woodhall—Painting pipes
2583 J. Hamilton—Polished wood, &c.
2584 J. Hill and A. M. Strathern—Cutting wood
2585 J. Hall and G. Hall—Sheet-metal rollers or drums
2586 J. Brunton and R. C. Rapier—Working railway switches
2587 J. J. Cousins—Registering pool and other games of skill
2588 R. Elsdon—Locomotive engines
2589 R. G. Rainforth—Consuming smoke
2590 J. Henderson—Refining iron
2591—G. Symes—Gas
2592 C. Necker—Sewing machines

Dated September 30th, 1870.

2593 D. Hanna—Sewing machines
2594 H. C. Carver—Separating mixed substances, &c.
2595 H. Stapfer—Concentrated and preserved potatoes
2596 G. H. Funck—Valve apparatus
2597 W. Hamer and J. Davies—Heating brine
2598 J. J. Ashworth—Indicating the distance travelled by vehicles
2599 J. Phillipson—Carriage windows
2600 T. R. Crampton—Furnaces
2601 J. Proven—Putting driving straps upon drums
2602 T. Foulkes—Signals
2603 A. H. Brandon—Spinning machinery
2604 F. Watkins—Fastenings for the ends of hoops
2605 W. Brown—Paddle wheels
2606 J. Eiflander—Ships of war, &c.
2607 E. Wylam—Improved oven

Dated October 1st, 1870.

2608 W. R. M. Thomson—Utilising the heat of steam, &c.
2609 J. C. Fellars—Blacking
2610 W. Birch—Machinery for opening, &c., calico
2611 T. J. Powers—Ammunition
2612 J. Ward—Working locomotive engines
2613 B. and J. Siddall—Steamers
2614 J. Moody—Saddles
2615 G. Haseltine—Polishing machine
2616 E. D. Thomas—Raising and lowering weights
2617 F. Wilkinson—Applying tubes of paper to spindles, &c.
2618 F. J. Head—Cocks and valves
2619 J. Yule—Motive power engines
2620 L. Sterne—Securing tyres to wheels
2621 E. A. Pontifex and J. Barton—Cutting sugar canes

Dated October 3rd, 1870.

2622 T. Clemetson and J. Deere—Fuel
2623 E. Leach—Improved hydrometer
2624 L. Cooper—Transporting passengers, goods, &c.
2625 J. B. Stoner—Floating lighthouse
2626 W. Hoyle, J. Harrison, and R. Rothera—Spinning and twisting
2627 T. Aveling—Tyres of the wheels of locomotives
2628 G. Haseltine—Machine for tapping the threads in nuts
2629 E. Butterworth—Furnaces

Dated October 4th, 1870.

2630 R. W. Thomson—Elastic tyres
2631 J. H. Rothwell—Stop valves
2632 T. W. Overman—Administering medicine to horses
2633 G. Haseltine—Pumps
2634 A. V. Newton—Chamber utensil
2635 J. Winter—Filling glass bottles with soups, &c.

Dated October 5th, 1870.

2636 J. G. Tongue—Carpets
2637 C. Waddie—Printing press
2638 J. Dunstan—Firearms
2639 C. W. S. de Bay—Movable fort
2640 D. Mole—Spring hinges
2641 H. Deacon—Sulphuric acid
2642 A. V. Newton—Galvanic batteries
2643 W. R. Oswald—Ventilating stoke holes of ships
2644 H. H. Murdoch—Looms

Dated October 6th, 1870.

2645 Dr. O. Burgh and A. Schiebel—Electro dynamic apparatus
2646 J. Lumley and W. Parnell—Washing machines
2647 T. Jennings — Revolving heels for boots and shoes
2648 H. Bradwell, J. Bullock, and G. Whittaker—Looms
2649 W. T. Henley and D. Spill — Compounds of collodion
2650 W. Evans and T. Price—Tin plates
2651 C. Burnett—Raising and measuring beer, &c.
2652 G. Haseltine—Weighing scales
2653 C. F. Kirkman—Treating sewage
2654 S. Chatwood and T. W. Tobin—Safes, strong rooms, &c.

Dated October 7th, 1870.

2655 S. and J. Randall—Agricultural drills
2656 M. J. Roberts—Stopping or regulating the flow of fluids
2657 H. Vosper—Direct acting steam engines
2658 J. W. Fletcher—Fuel for facilitating the soldering of the joints of electric telegraph wires
2659 W. F. Dando—Apparatus for advertising, &c.
2660 G. Haseltine—Obtaining solar measurements of latitude
2661 J. G. Stapelton—Manufacture of tobacco pipes
2662 G. Haseltine—Bows, scarves, &c.
2663 J. H. Johnson—Bearings, packing for shafts, &c.
2664 A. McNeil and W. Wheaton—Revivifying the materials used for the purification of gas

Dated October 8th, 1870.

2665 L. B. Bertram—Attaching stamps to letters
2666 C. A. Wheeler—Protective opening for parcel or letter-box
2667 H. Lyon—Indicating quantities
2668 W. E. Newton—Continuous process for treating the ores of metals
2669 J. Holding—Looms
2670 A. S. Rake—Condensing the smoke and products of combustion
2671 W. Ellis—Cutting wood to any required pattern
2672 A. Frankenberg—Measuring the flow of liquids
2673 A. Frankenberg—Cooling or refrigerating liquids
2674 J. Needham—Firearms

Dated October 10th, 1870.

2675 G. C. Wilson—Improvements in breech loading firearms
2676 J. Lawson—Preparations of food for horses, &c.
2677 J. Mason and A. Parkes—Manganese and alloys of manganese
2678 W. R. Lake—Steam engines
2679 N. Domaille—Stoppers for bottles
2680 J. R. Greaves—Improved candle
2681 S. E. Asquith and F. A. Greenwood—Spinning wool

Dated October 11th, 1870.

2682 J. Kenyon—Improvements in looms for weaving
2683 J. Boisset—Improved apparatus for gymnastic exercises
2684 J. Shand—Single cylinder steam or other motive power engines
2685 T. G. Tolson—Saving life and property at sea
2686 P. Newland — Improvements in the construction of cupola furnaces
2687 C. J. Letts—Producing divers coloured letters, &c.
2688 M. Henry—Improvements in electro telegraphic apparatus
2689 J. Hodgson—Improvements in looms for weaving
2690 A. C. Andrews—Certain descriptions of boots and shoes

Dated October 12th, 1870.

2691 L. F. Tavernier—Combing and preparing cotton, &c.
2692 J. Lightfoot—Printing and dyeing textile fabrics
2693 E. T. Hughes—Dressing or sizing warp threads &c.
2694 J. H. Smith—Sewing machines' combination of stitches
2695 A. Mason—Making up pulp or half stuff from wood
2696 C. Lowe and W. P. Harper—Metallic surfaces, &c.
2697 F. J. Bugg—Improvements in pressed leather
2698 T. White—Manufacture of boots and shoes, &c.
2699 J. Clark—Improvements in rolling iron and other metals

Dated October 13th, 1870.

2700 R. Lakin, W. H. Rhodes, and J. Carpenter—Machinery for preparing, spinning, and doubling cotton, &c.
2701 J. A. Philips — Securing corks and stoppers in bottles
2702 J. Onions—Cooking, and in apparatus for cooking
2703 W. Greaves and G. Greenwood—Looms for weaving
2704 D. M. Weston—Construction of self lubricating hubs, &c.
2705 D. M. Childs — Training hops, the sockets for the poles, &c.
2706 T. Huckvale—Bridles
2707 H. Huthnance—Ordnance and projectiles therefor

Dated October 14th, 1870.

2708 F. Arnold—Envelope or pattern post wrapper
2709 G. S. Kirkman—Shoreing or strutting earthworks
2710 J. Bain — Improvements in double acting pumps
2711 J. L. Heward—Machinery for the manufacture of nails
2712 W. B. Thompson—Packing fibrous materials in ships
2713 C. Mansel—Improved safety knitting sheath
2714 F. L. H. Dansell—Charring wood, peat hones, &c.
2715 R. H. Davis—Packages or receptacles for sulphuric acid
2716 W. B. Gedge—Improvements in the construction of perambulators, &c.
2717 J. Jordan — Furnaces for burning coal, &c.
2718 T. Fearn—Apparatus for raising and lowering weights
2719 J. H. Brown—Manufacture of leather from the refuse of tanned hides
2720 J. H. Brown—Manufacture of leather paper

Dated October 15th, 1870.

2721 J. C. Haddan and J. Imray — Taking votes
2722 J. F. Hart—Steam washing and disinfecting machine
2723 A. Wenner—Double throstle and other flyers
2724 W. F. Murray and T. D. McFarland—Shaping plastic materials
2725 D. Greig and M. Eyth — Ploughing, harrowing, &c.
2726 R. A. Gooding—Simultaneously printing and delivering checks

Dated October 17th, 1870.

2727 G. Murray—Ploughs
2728 G. Batty—Preparation of concentrated food
2729 G. B. and G. T. Galloway—Production of motive power, &c.
2730 J. Stalvies—Gas stoves for heating and warming rooms
2731 J. S. Greenhow and G. O. Gooday—Secret correspondence
2732 M. Smith, G. T. Waldener, and A. C. Lee—Raising wine, &c.
2733 D. Laidlaw and J. Thomson—Applying compressed air to propel omnibuses
2734 A. C. Bamlett—Reaping and mowing machines

Dated October 18th, 1870.

2735 B. Blakey—Looms
2736 J. K. Dallison—Leaf-guerd and book-mark
2737 C. Cook—Boxes for containing furs
2738 S. Collins—Guiding the material for the construction of button-holes
2739 N. S. Walker—Manufacture of combined lead and tin pipes
2740 J. B. Robertson—Sewing machines
2741 W. Mather—Apparatus for breaking nuts and separating the husks and shells from the kernels
2742 J. Tomlinson—Preparing cotton and other fibrous materials
2743 W. E. Newton—Saddle cloths and horse clothing and blankets
2744 A. V. Newton—Stocks of muskets
2745 P. Toepler—Cleaning wool and separating the grease therefrom

Dated October 19th, 1870.

2746 W. F. Reynolds and J. A. Mays—India-rubber or caoutchouc tires for wheels
2747 J. Rhodes and J. J. Richardson—Preparing and combing wool, &c.
2748 B. D. Healey—Applying heat to steam boilers
2749 J. Wright—Preparing and printing floor-cloths
2750 J. H. Dallmeyer—Opera glasses, &c.
2751 W. E. Gedge—Combining the functions of a bung and of a self-acting vent peg
2752 G. George—Numerical registering and indicating apparatus
2753 J. W. Naylor—Manufacture of woven bags
2754 R. W. Fraser—Automatically-rotating instrument applicable as a toy

Dated October 20th, 1870.

2755 J. H. Johnson—Illuminating and ventilating roofs and gratings or plates
2756 W. Twining and J. Dangerfield—Manufacture of toilet or dress pins and other pins
2757 J. I. Evans—Cleansing and brushing tin plates
2758 J. Howard—Manufacture of beet, &c.
2759 F. Garside—Planking or felting hat bodies
2760 W. Paton—Constructions of elastic, &c.
2761 A. Ford—Colouring India-rubber, &c.
2762 W. R. Lake—Manufacture of oil, &c.
2763 M. A. Muir and J. McIlwham—Wrought-iron railway sleepers, &c.
2764 W. Clark — Apparatus for winding thread on to bobbins
2765 J. H. Johnson — Construction of bridges
2766 W. Bancroft and J. Wood—Ornamental metallic chains
2767 F. Parkes—Ploughshares
2768 I. Nash—Hay knives
2769 A. Henry—Breech-loading fire-arms
2770 I. Farrell—Guidance or steerage of velocipedes
2771 J. Russell—Water-heating apparatus

Dated October 21st, 1870.

2772 J. McNaught and W. McNaught—Apparatus for washing, &c.
2773 H. H. Stone—Paper bags
2774 C. H. Moberly — Construction of evaporating apparatus
2775 J. R. Williams—Ground anchor
2776 A. Frankenberg—Construction of side-boards
2777 G. Taylor—Hoops for wheels of carts, &c.
2778 J. Stephens—Heating liquids
2779 B. Marsden—Skates
2780 D. Whale—Disconnector for vehicles and harness
2781 W. Brown—Sewing machines
2782 W. E. Newton—Salt

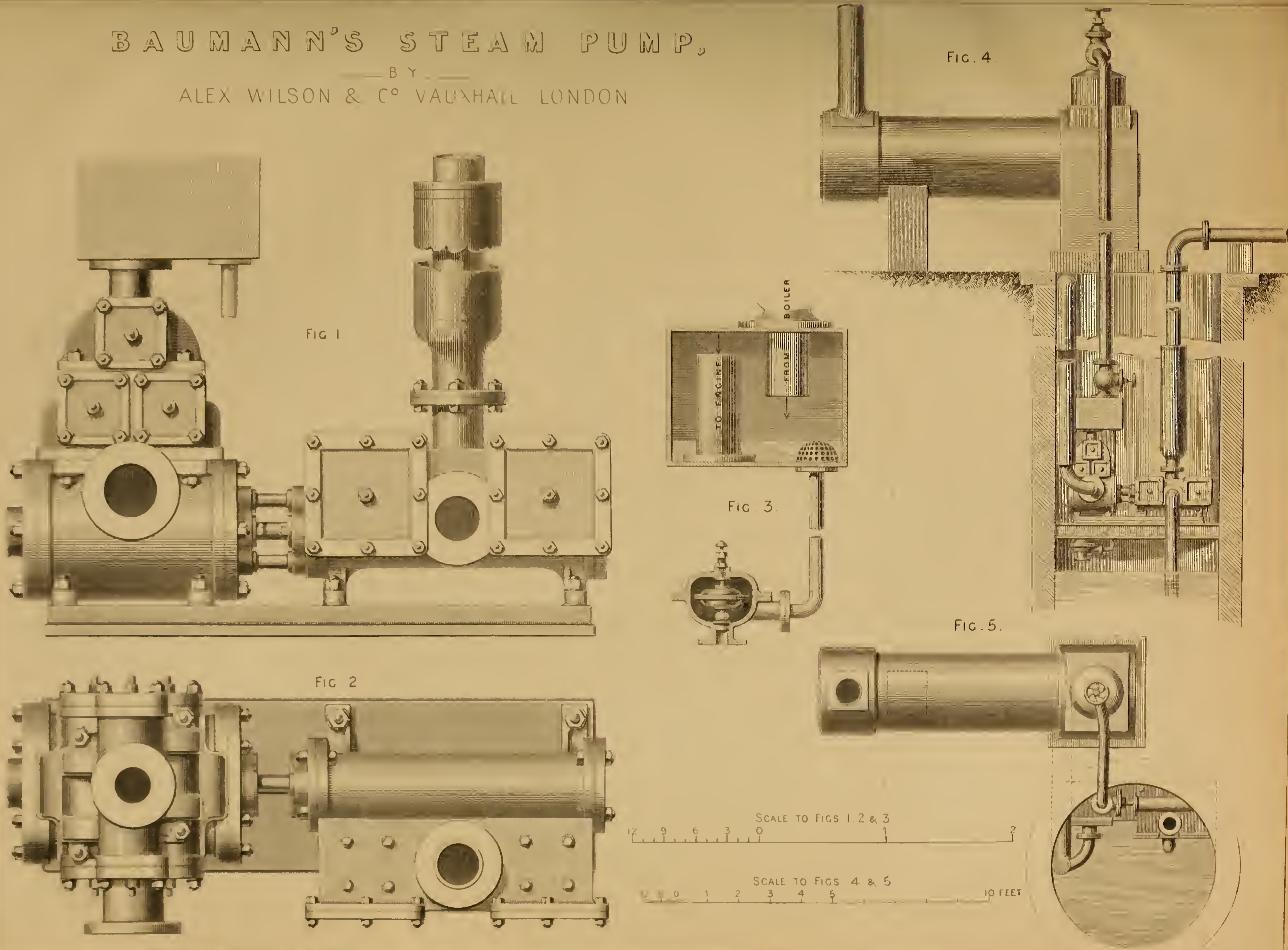
Dated October 22nd, 1870.

2783 J. Hoyle—Anti-friction metal for the bearings and steps of shafts, &c.
2784 W. Fletcher—Liquids

BAUMANN'S STEAM PUMP,

BY

ALEX WILSON & C° VAUXHALL LONDON



G B Smith, sc

THE ARTIZAN.

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1st DECEMBER, 1870.

PUMPING ENGINE FOR LEATHERHEAD WATERWORKS.

Designed by Alexander Baumann, and constructed by Messrs. A. Wilson and Co., Vauxhall.

(Illustrated by Plate 367.)

Of the various branches of engineering which have lately assumed sufficient importance to constitute distinct trades of themselves, there is one which especially merits attention, in consequence of its almost universal demand amongst steam users. As a natural result, such a demand called forth a corresponding effort on the part of engineers to meet it: hence the number and variety of schemes to effect one particular object. We are referring to the construction of small steam-pumps. Small steam-pumps are now in the market in two different shapes, viz., fly-wheel pumps, and direct-acting pumps; by which latter term is meant steam-pumps without a fly-wheel.

Tracing back the history of the trade through the last few years, we shall see what sort of pumping-engine was actually in demand, and how, by necessity, the fly-wheel pump, which is the elder of the two, was followed by the direct-acting pump. The latter must now be considered as having gained its ground amongst a great number of articles which are wanted in almost every factory where steam is used.

Perseverance—the first condition of success—will go a long way in all undertakings; and we are of opinion that those manufacturers who have succeeded in creating for themselves a circle of customers for the new class of articles about which we are going to speak, have well deserved the measure of their success.

When these pumps first came into use there was a new technical term invented, and they were called "donkey-pumps," in reference, we believe, to their diminutive size; although of late years the term is not always appropriate. A donkey-pump may be said to be a small steam-pump, the piston-rod or ram of which is directly moved by a steam-piston, the pump being used for feeding a steam-boiler, and sometimes for doing some other work of secondary importance.

It was pointed out some years ago that there was a great advantage in having small independent steam-pumps, and the users of steam power seemed eagerly to purchase and apply the various pumps which were offered. The pump, once called into existence, soon proved itself applicable to various purposes, the main consumption being nevertheless realised in factories where much steam power is used.

It would be invidious to name the various makers who brought out new contrivances; many of them offered recently-patented steam-pumps of so primitive a construction that it is surprising how they found buyers at all; but the article was in demand, and the most curious-looking things were offered and sold. There was a general impression, however, that the thing required was not merely a small ordinary steam-engine driving a pump, the whole constructed as compactly as possible; but there seemed to be an idea that a new variety of steam engine ought to be made which should have no rotary motion at all, the main object being the reciprocating motion of the pistons.

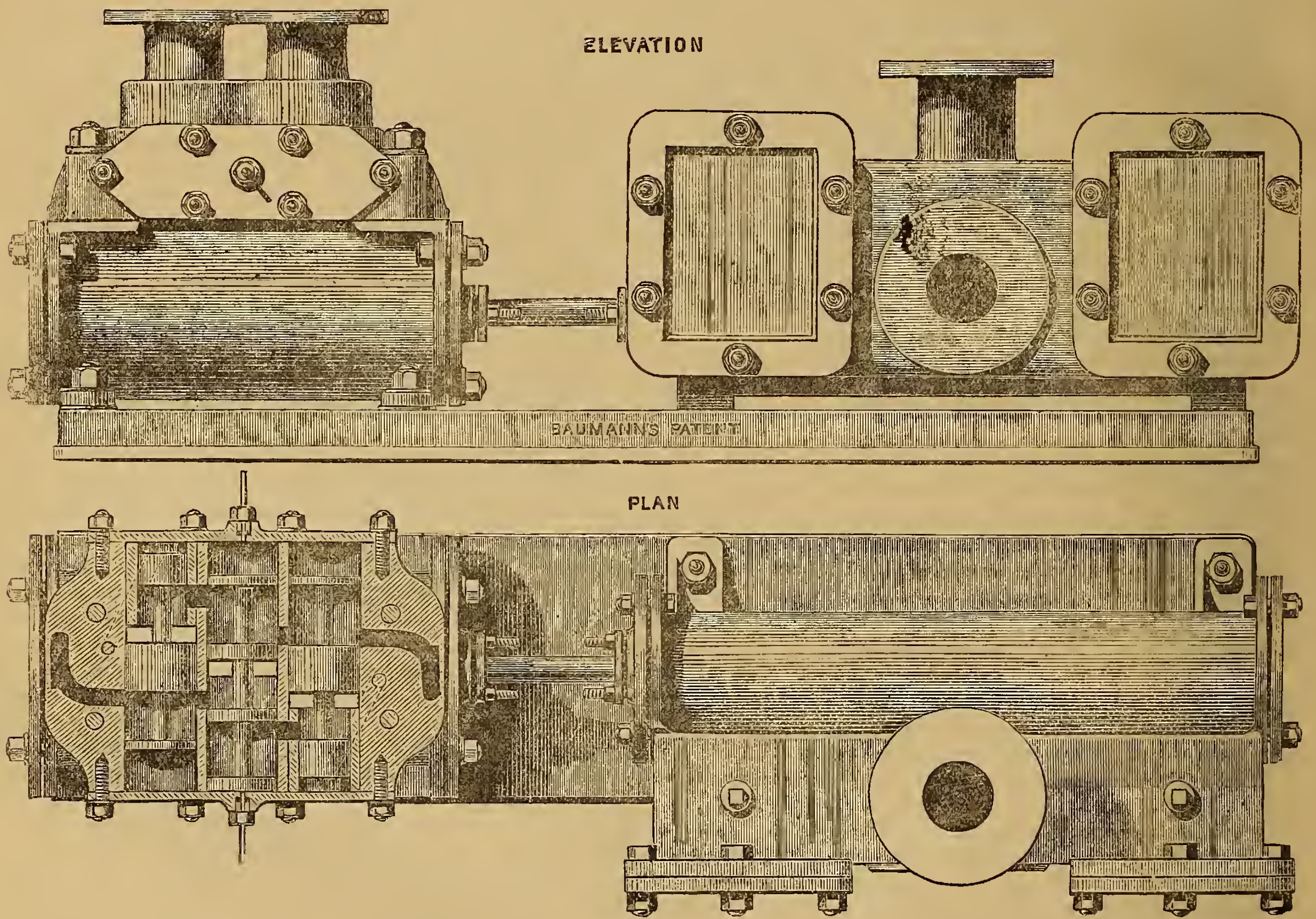
Against new contrivances a compactly arranged steam-pump constructed upon well-known principles had, of course, a great advantage at first, and there are always buyers who decidedly prefer an article they thoroughly understand to an engine which is acknowledged to be a new invention, and which they have to study before they can work it to their satisfaction. Inventors, however, who tried to construct a new variety of engine, which should better satisfy the demand evidently existing, were not mistaken in their views. The fly-wheel, without which a rotary motion could not easily be maintained, takes a good deal of room, and it was only wanted for driving the eccentric and slide valve, expansion not being considered necessary. The thing actually required was a slide valve which admitted the steam to one end of the cylinder and then to the other, exhausting accordingly; and it is not necessary that this valve should be travelling all the while backwards and forwards. How this steam piston can be stopped at the end of the stroke by something quite as effective as a crank we shall see presently. We must, however, dwell for a moment upon the question of expanding the steam, for comparatively few seem to see clearly how matters stand in this respect.

Many manufacturers of donkey-pumps hold, that if the steam-piston and the pump-piston are connected together, a high degree of expansion is impossible. From theory alone, this statement must be denied; calculation will give the size of the fly-wheel necessary to overcome any sort of resistance, as long as the work expended upon the steam-piston is greater than that consumed by the pump-piston. We are aware, indeed, that there was at the last *conversazione* of the Institution of Civil Engineers a donkey-pump exhibited; and diagrams taken from it, show, that it cuts the steam off at one-eighth of the stroke, while it also condenses the steam. It works at a very high speed, so that the suction-pipe must be very much larger in diameter than the delivery-pipe, and the valves of the pump are superseded by a slide valve, because they would not work at such a speed. We see, therefore, that this *can* be done, and we also know that this pump works well. But, if we are glad to see a highly perfected engine work in an equally satisfactory manner, we cannot, at the same time, forbear looking out for a donkey-pump that will stand rough treatment, and that can be repaired by a common mechanic. The donkey-pumps which the various makers and inventors are presumed to offer to the public, are supposed to work at all pressures; to work, in fact, as long as steam is let into them; which would almost be an impossibility with a high rate of expansion. So then, the donkey-pump of the day, if we may use the term, must be simple, durable, it need not be expanding, and, above all, it must work at all reasonable steam pressures. We would, however, say a few words of the various systems of direct-acting pumps only, now in use, because this part of the question is rather new, and therefore experience is wanting. It is evident that if we do away with the crank, we must have something else to prevent the running of the steam-piston against the covers; and, consequently, we must cushion the steam-piston by shutting off the exhaust at the proper time. Some makers give a certain amount of lead; but the lead they give to the valve, if not excessive for small speeds, will be ineffective for high speeds; we think, therefore, that a steam cushion at the end of the stroke ought to be provided for. It is done in some direct-acting pumps and in our opinion that class only can be recommended as being constructed on sound principles.

A great point in favour of direct-acting pumps is the firmness and simplicity of the moving parts which brings this class of pumps so near to the most perfect pump possible, in which the steam would lift the water directly, without the intervention of mechanism. It is shown, indeed, that in this class of engine, the loss of power from friction is reduced to a minimum; some of the specimens we have seen move with a pressure of four pounds per square inch only. Repairs, being as a rule in proportion to the number of working parts, will of course be inconsiderable in a direct-acting pump compared with a steam-pump of ordinary description.

In Plate 367 is illustrated a direct-acting pump, which, we think, worthy the attention of our readers as being one of the most highly perfected engines of this class; Fig. 1 being an elevation and Fig. 2 a plan. The pump here shown has just been constructed by Messrs. Wilson and Co., of Vauxhall, for the Leatherhead Waterworks, and is upon the system patented by Mr. Baumann. The peculiarity of this description of pump consists in its "steam-moved" piston valves, which the inventor has so arranged, that there are absolutely no dead points at any part of the stroke. As soon as the steam is let on to the engine it will begin to work, no matter in what position the steam piston may be in, and as far as we could see when examining one of these pumps, it is impossible by fair means to make it "stick." The working of the valves is shown in the accompanying engraving, which represents an engine in elevation and plan, the steam chest being in section, showing the three piston-valves and the various steam-ways. These piston-valves are moved by the pressure of the steam itself, and they have no connection with each other or with the main piston. The piston-valve in the middle is the main valve, the two outside differential piston-valves are called the leading valves. Each of the two leading valves moves in its turn at the end of each stroke. Steam enters the apparatus from above at the blank space in the middle of the steam chest, and the exhaust pipe is connected with the two other blank spaces on the leading valves.

When the pistons are as represented in the engraving steam enters in the middle, and passes into the left-hand end of the main cylinder, the exhaust leaving the main cylinder at the opposite end. The piston, therefore, moves from left to right until it has passed over a small steam-way, shown in dotted lines, which admits the steam in the reduced face of the differential leading valve. The left side leading valve will not move, because the steam pressure acts upon both its faces, but the right side leading valve will be shifted as soon as the main piston has passed near the end of its stroke, over the corresponding steam passage; the larger face of this right side leading valve has no pressure acting upon it, being in the exhaust. The shifting of this leading valve shuts off the exhaust passage, and produces a steam cushion for the main piston, while the steam which has shifted it, enters into the neighbouring compartment and shifts the main valve, the small outside discs of which are not completely steam-tight, as is the case with the small discs on the leading valves. The main valve being thus reversed, steam finds its way through the steam-passage, and acts on the large face of the leading valve throwing it back into its former position; and now a new stroke begins. To avoid noise, this steam-chest is packed with india-rubber, protected against the steam by a sheet of thin rolled brass. The advantage of having this thin sheet of brass consists in allowing the joint to be broken at any time, for inspecting the valves, without tearing the india-rubber.



In Plate 367 a similar pump is represented in elevation and plan, (Figs. 1 and 2), with the only difference that because of the comparative shortness of the steam cylinder, the designer was obliged to raise the middle valve above the two outside valves. In Figs. 4 and 5 is shown an elevation and plan of the general arrangement of the waterworks at Leatherhead. The steam from a semi-portable boiler enters the pump after having passed through a rectangular chest, shown in detail in Fig. 3, where it leaves its condense water. This water is taken away by means of a peculiar description of steam trap invented by M. Bünger.

This steam trap consists of an outer casing containing a flattened circular vessel made of thin metal, and filled with water. The lower surface is connected to a double beat valve, while the top is attached to a screw spindle, passing through a stuffing box on the outer casing. By means of this screw, the height of the internal vessel is so adjusted that when the water contained in it is comparatively cool, the double-beat valve is open, but when this water is heated in consequence of the outer casing containing steam the expansion thus occasioned — which can only act downwards—closes the valve. As soon, however, as a sufficient quantity of water accumulates in the casing to cool the internal vessel, the contraction opens the double beat-valve and discharges the water, the action being similar to that of a thermometer. It is well known to engineers that the common description of steam trap consisting of a hollow ball or float attached to a valve, very soon becomes useless, in consequence of water gradually finding its way through the metal of the ball and destroying its buoyancy. As, however, in this case, the part representing the float is already filled with water, it is not subject to such deterioration.

The exhaust steam from the engine, instead of passing away through a steam-tight pipe, is blown into a large pipe or funnel, as shown in Fig. 4, which is open at the bottom, the end of the exhaust pipe being made slightly conical. The draught thus occasioned thoroughly ventilates the well, and as the upper end of this larger pipe leads into the ashpit of the boiler, any deleterious gases are consumed or neutralised.

Upon referring to Figs. 4 and 5 (Plate 367) it will be seen that the machinery is remarkably compact, the entire engine and pump standing upon a girder, and occupying considerably less than half the area of a well five feet in diameter. The steam-piston has a diameter of twelve inches, the pump-piston five inches, stroke twelve inches; the contemplated speed is thirty double strokes per minute. In ordering the boiler for his pumps Mr. Baumann calculates it large enough to give a volume of steam ten per cent. greater than the volume required by the steam-piston, at a pressure double that which would be sufficient for equilibrium. As this pumping engine will be at work in a short time, we will publish in a future number the results it actually gives.

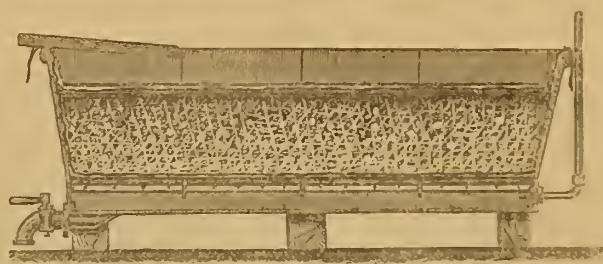
CHARCOAL FILTERS FOR A SUGAR HOUSE.

(Continued from Page 242.)

Having by means of defecation in the clarifiers, obtained a comparatively clear and neutral liquor, it now becomes the question whether the water shall be at once evaporated without endeavouring, except by the mechanical process of boiling, to increase the purity of the juice, or whether it is worth while to carry the process of clarification still further. As regards this question, a great deal must be left to the judgment of the manager or proprietor of the sugar-house. In some cases, the canes may be so good, and the clarification performed so thoroughly, that by means of some one of the evaporating apparatus to be hereafter described, a first class grocery sugar may be obtained. In other cases, although equal care may have been exercised, the juice when evaporated will yield but a small proportion of sugar of an inferior colour, and a large quantity of molasses. This latter result, is probably owing to the large quantity of albumen and mineral salts held in solution, as it is usually found that the juice of "plant" canes, which from their vigorous growth naturally absorb a larger proportion of mineral salts, is more difficult to manipulate than the juice from "ratoons."

There have been various methods proposed for the further clarification of the liquor by means of filtration. The first plan was, we believe, to filter it through beds of coarse sand and shingle, the idea being most likely taken from the filtering beds of waterworks; but as might have been expected it was soon abandoned. Another method has been extensively adopted, viz., filtering through bag filters, but this again, though useful to a certain extent, is entirely a mechanical process and is by no means perfect even for that purpose. The only filter that will meet the requirements satisfactorily, is undoubtedly the well known animal charcoal filter, as it not only purifies the liquor mechanically, but also absorbs or decomposes nearly all the deleterious compounds held in solution. As we are now treating upon the manufacture of a good saleable, but unrefined sugar we are not going to propose a complete system of charcoal filtration. That, indeed, is more advantageously carried on at a later stage in the manufacture; but we feel convinced that a somewhat rough and ready filtration through animal charcoal at this stage of the manufacture, greatly increases both the yield and the quality of the sugar.

In order to explain our views more completely we illustrate in the accompanying engraving a charcoal filter suitable for this purpose. It



consists of a galvanised wrought-iron pan, about twelve feet long by four feet wide, and four feet deep, slightly tapered at the sides. A false bottom, consisting of stout wire gauze, or a perforated plate, stiffened by means of cross stretchers, is placed about six inches from the bottom, and covered with a coarse blanket, or other suitable material. Upon this is evenly distributed the animal charcoal, previously moistened with soft water, to within about seven or eight inches of the top of the pan. A sheet of fine wire gauze is then placed upon the top of the charcoal, and the whole covered with a cloth of the same material from which filter bags are usually made. As will be observed on reference to the drawing, an air tube with an open top, which runs up a short distance above the pan, is provided, for the purpose of allowing the escape of the air enclosed between the two bottoms; a cock for drawing off the filtered liquor being situated at the other end of the pan. The charcoal should not be too fine, or the liquor will not run through quickly enough. The depth of charcoal here recommended is not sufficient to remove all the colour from the liquor, but, as before remarked, is only intended to remove a sufficient amount of colour to give a first-class grocery sugar, and also to free the liquor from most, if not all, of its impurities. As far as we can judge, this process will also prevent the occurrence of that disgusting insect the *acarus*, or sugar louse, which compels many people to use refined sugar instead of the far superior flavoured sugar direct from the mill. Amongst other properties possessed by animal charcoal may be mentioned the neutralisation of any acid that may still remain in the juice through the agency of the calcic carbonate contained therein. According to M. Bodenbender :—

(1.) The capacity which granular animal charcoal possesses of absorbing salts and their solutions is for the most part a physical property.

(2.) One part in weight of charcoal absorbs a larger proportion of salts from a concentrated than from a diluted solution; on the other side the proportion absorbed from a constant quantity of salts is more considerable, when this quantity is more diluted than when it is in a concentrated solution.

(3.) The presence of sugar has only a slight influence on absorption.

(4.) The salts of potass are absorbed in smaller proportion than the salts of soda.

(5.) The absorption of salts varies according to their composition; it increases in the order of the following list of salts being smallest in the first on the list.

Chloride of	Potassium	Sulphate of	Potash
,,	Sodium	,,	Soda
Nitrate	Potash	,,	Magnesia
,,	Soda	Carb.	Potash
Acetate	Potash	,,	Soda
,,	Soda	Phosphate	Soda

(6.) A chemical action of the charcoal has been observed with respect to some carbonates, oxalates and alkaline nitrates; it is determined by the presence of sulphate and of phosphate of lime in the charcoal.

(7.) Charcoal saturated with a certain salt is still able to absorb another salt from solution within certain limits.

(8.) There is less absorption from a salt when in contact with the charcoal for a short time, than when the contact is prolonged within certain limits.

THE GRAVING DOCK FOR MALTA.

The whole of the 32 presses belonging to the hydraulic dock now in process of construction at Malta have been successfully cast at the Liverpool works of the contractors, Messrs. Emmerson and Murgatroyd. These presses, or cylinders, were cast perpendicularly and in one piece of 36ft. in length and 14 tons in weight. The lift of this dock is composed of two rows of cast-iron columns, or cylinders, sunk firmly in the ground in about 27ft. of water. Between these rows is a clear space of 60ft. in width and 310ft. in length (which forms the dock), and between each column a space of 20ft., measuring from centre to centre. The practical working length of the dock, however, is 350ft., as vessels may project at each end. The 32 cylinders contain as many connected hydraulic presses. These are attached to the girders of a wrought iron platform or gridiron, which hangs between the two rows of cylinders, and can thus be raised or lowered with a vessel upon it as the presses are worked upwards or downwards in their cylinders by the force-pumps. The force-pumps are set in motion by an engine housed on a platform at one end of the dock. The columns do not require to be fixed with any extraordinary strength or accuracy. The suspended load always tends to bring them vertical, and they support no weight, but are simply guides for the cross-heads of the presses moving in slots.

This lift is calculated to raise a vessel of 3,000 tons register clear of the water. The vessel lifted does not immediately rest on the platform hanging between the columns, but is supported by bilge-blocks on a large iron pontoon placed on the platform and submerged full of water, which runs off through valves opened when it is raised. The pontoon is then buoyant, and on the lowering of the gridiron can be drawn out with the vessel upon it and moored in a convenient berth. Another pontoon and vessel can then take the places of the first, and so on, according to the supply of each. The Victoria Dock has seven pontoons, which can float vessels ranging from 930 to 3,000 tons. In seven years 1,055 vessels, of an aggregate tonnage of 712,380 tons, have been lifted without a single casualty, and at a cost averaging £3 each.

CENTRAL SHAFT.—HOOSAC TUNNEL.

At last, after years of toil, and at a cost of close upon half a million of dollars, the great central shaft of the Hoosac has reached the grade of the tunnel—1,030ft. below the natural surface. This shaft is elliptical, the transverse diameter being 27ft., and the conjugate 15ft., passing the entire depth through a compact mica-slate formation intermixed at intervals with white quartz. At the commencement of the present contract with the Messrs. Shanly, there required to be done 447ft. This has been accomplished since June 1, 1869—say in 15 months—giving a monthly average of 29·8ft. The largest month's work was 38ft. At intervals of about 18ft. are floors of heavy timbers, supported by "hitches" cut in the rock, connected by ladders, in case of accident to the hoisting apparatus, and forming supports for the wooden guides, in which the crosshead travels, under which is suspended the boiler-plate iron bucket of a capacity of about 400 gallons. The work has been impeded slightly by water, of which the shaft makes nearly three inches per hour. To raise this water, an engine of 60-horse power is constantly working, pumping all the water which collects as far down as 650ft., caught in tanks by sloping "drip-roofs." Below this, the water on the bottom has been hoisted in the iron bucket, a bucketful being sent up by the miners whenever the quantity became inconvenient. Now, the shaft being at grade, a sump will be sunk, and a water bucket with bottom valve used, thus avoiding the tedious task of baling into the bucket by hand.

Workmen are now employed trimming the sides of the shaft, and preparing the guides for a wooden cage to be substituted for the bucket so soon as the headings, east and west, at the bottom, are sufficiently advanced to use rock cars, when the rock will be raised to the top direct from the headings, cars and all.

The shaft being at grade necessitates, probably, the most delicate and responsible professional act an engineer may ever expect to meet, it being necessary to lay down a line less than 27ft. in length at the bottom of a dripping dark shaft 1,030ft. deep, so that both ends of the line being produced shall coincide with the terminal points of the tunnel, each being distant over 12,000ft. from the centre of the shaft. To increase the initial difficulty, the top of the shaft is on the summit of a rugged mountain, from 1,500ft. to 1,800ft. above the grade of the tunnel at its termini. It is no light responsibility to assume charge of this operation. The State of Massachusetts has had manufactured a colossal transit instrument, of the most elaborate and perfect construction, costing 3,000dols. The most accurately verified lines have been laid down over the mountain, extending long distances beyond in both directions to the tops of neighbouring mountains. By the accuracy of this instrument and its manipulation, the line of 27ft. (the transverse diameter of the shaft) will be permanently defined, requiring wonderful exactness, and from its extremities the plummet alone can reach the bottom of the shaft. These plummets must of necessity be weighty and beautifully poised, and will require to be suspended in oil to produce perfect rest and protection from the faintest vibration of the air. The most delicate cords, consistent with strength, must be used to suspend them, and after all is done that science can suggest (being perfect as to theory) any intelligent mind can understand how delicate and fraught with danger is the practical part of the operation to the engineer, and what grave effects the slightest error would produce on so small a base as 27ft. It is quite possible the motion of the earth may effect the plummets more or less; but this point has not yet been thoroughly investigated.

The details of working in this shaft, and otherwise about the tunnel generally, would require a series of articles, but the above remarks may be of some interest, and suggest the difficulty last noted, giving civil engineers something to think over.—*Scientific American.*

TRIAL TRIP OF THE "ABYSSINIA."

The *Abyssinia*, breastwork Monitor, 1,849 tons, 200-horse power of engines, carrying two double-gun turrets, and driven by twin screws, built for the defence of Bombay, to order of the Secretary of State for India, by Messrs. J. and W. Dudgeon, of Millwall, under Admiralty supervision, was put through her final trial of machinery and speed over the measured mile off the Maplin Sands, on the 1st ult., previous to her sailing for Bombay.

The ship's draught of water was 13ft. 7in. forward and 14ft. 8in. aft, giving a mean draught of 14ft. 1½in. At her load line the ship will float at 15ft. forward and aft, with the main deck having a freeboard of 3ft. A strong wind prevailed off the Sands during the time the ship was being tried, and a lumpy sea was running, but the results were considered very satisfactory by all the officials on board, the ship under full boiler power, without being pressed in any way, or the power of her engines brought out to their full extent, averaging as a mean of six runs made over the measured mile 9·600 knots per hour. Under half boiler power she realised a mean speed of 7·827 knots. The mean revolutions of the engines at full boiler power were 117·5 per minute. In trying the ship over circles after the speed trials had been concluded, a half circle was made to port in 2min. 12sec., and the full circle in 4min. 52sec. To starboard the half circle was made in 2min. 10sec., and the full circle in 4min. 42sec. The angle the rudder was put over in each distance was 30 degrees. In testing the action of the engines, in reversing their motion to signal from the hurricane deck, the results obtained were equally satisfactory with those, connected with their power and speed; each pair to port and starboard stopping dead in 15sec., starting astern to full speed from rest in 5sec. and 6sec. respectively, and changing from full speed astern to full speed ahead in 4sec. and in 6sec. respectively. The engines were constructed by the builders of the ship, and consist of two pairs of inclined cylinders, direct acting, the diameter of the cylinders being 34in., and the stroke of the pistons 21in. They drive two three-bladed screws, each of 9ft. 6in. diameter. The distance between the centres of the screw shafting is 13ft. 6in.

The *Abyssinia* is one of three vessels of the low freeboard Monitor type that have been built for the defence of our colonial harbours, the *Magdala* being the second vessel, also for the defence of Bombay, and the

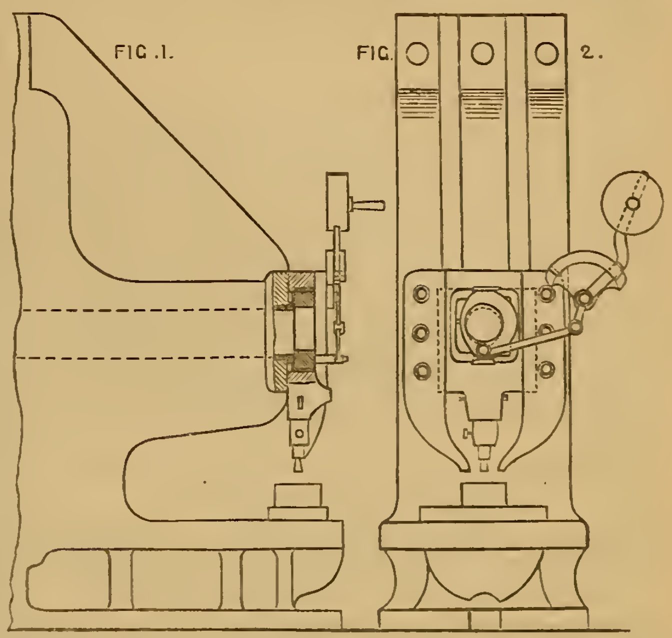
Cerberus, which sailed from the Nore on the 29th of Oct. for Melbourne, being the third. The two latter exceed the *Abyssinia* in tonnage and engine-power, but all three are exactly alike in design and arrangement of their decks and turrets as low freeboard Monitors, carrying their turrets inside an armour-plated breastwork, or smaller deck built upon the main deck. In one very important respect, however, there is at present a very great difference between the *Abyssinia* and her consorts. The former floats purely and simply as a Monitor without rig of any kind aloft, and with only two light spars for signal staffs. The *Cerberus* and the *Magdala* are both bark-rigged for their voyage out, and with the certainty that sail power can under no circumstances be of any service to them, and very probably will be found to seriously imperil their safety. The *Cerberus* may or may not carry her spars and sails with her from Plymouth to Melbourne at all risks, but it is believed to be the wish of the Controller of the Navy to take the *Magdala's* masts out of her again and send her out to Bombay under steam alone, as the vessel will go out *viâ* the Suez Canal. The *Abyssinia* and the two colonial consorts mount each four 18-ton guns, a pair in each of their two turrets. In this vital respect the *Abyssinia*, although 300 tons smaller than the *Cerberus* and *Magdala*, carries the same weight of armament, and even stows a larger quantity of ammunition than the others. The length of the *Abyssinia* between the perpendiculars is 225ft., with an extreme breadth of 42ft. at the top of the freeboard, or covering in of the hull proper; the depth from this covering to the keelson being 12ft. 2in. This hull has a double bottom through its greater extent, divided into 44 water-tight compartments, which are again divided by nine water-tight bulkheads. Where the double bottom is not extended into the extreme ends at the bows and the stern, water-tight iron decks are introduced. The covering-in deck is composed of 1½in. iron plating riveted up in the usual manner on the rolled iron beams of the ship's frame, and over that 4in. teak planking. The armour plating round the hull consists of an upper and a lower strake, the upper being 7in. in thickness and the lower strake 6in. Upon this deck is built the upper or breastwork deck, which encloses within its elliptical walls of armour-plating the two turrets, conning tower, funnel and engine-room, hatchways, steering wheel, &c. The height of this breastwork deck from the main or covering-in deck is 4ft. 2in. The tops of the turrets project above the breastwork deck 6ft., and the guns are thus carried with the axis of their bore at about 11ft. above the water line with the ship at her load line. The breastwork is 107ft. long, and 36ft. 4in. wide amidships. It it plated with armour 9in. in thickness round the turrets, and amidships, round the funnel and its casings, with plating of 7in. The turrets have a clear interior diameter of 21ft. 3in., and each mount two 18-ton muzzle-loading rifled guns. The armour plating on the turrets is 10in. in thickness on the front faces and round the gunports, and 9in. on the rear faces. The pilot or conning tower rises to a height of 12ft. 6in. above the breastwork deck, and is, therefore, nearly 20ft. above the water. It is plated with 9in. iron, and weighs upwards of 70 tons. The two hatchways which give access, and air and light to a limited extent, to the ship below from the main deck outside and below the breastwork deck are iron cylinders, projecting upwards some 3ft., and formed of 6in. armour plates.

The ship was weighted with ballast, and inclined in the Millwall Docks, previous to her trial, under the superintendence of Mr. Barnes, of the Council of Construction to the Admiralty, to ascertain her angles of stability. The result was very satisfactory, as they give the distance between the metacentre and the centre of gravity at about 3·8ft.

IMPROVED PUNCHING MACHINE.

By J. J. Montijn, Jr., Fyenoord.

In the usual punching machines where the punch is actuated by means of an eccentric working in a square block, the motion of the punch is continuous. For plain work, and in the hands of a good workman this is not perhaps a disadvantage; but with difficult work it often happens that the punch does not allow time for the plate to be "offered" correctly. It then becomes necessary to withdraw the plate altogether to prevent the work being spoilt; when the whole operation of getting it into position, has to be begun over again. In order to prevent the loss of time incurred by having to withdraw the work, time must be allowed for its proper adjustment, and this can only be done by arresting the motion of the punch. The necessity for some provision for effecting this object has for a considerable time been recognised by several of our toolmakers, and many machines are now made with throwing out gear, but a great majority of those at present in use have no such provision. An ingenious arrangement for stopping the action of the punch, which also has the advantage of being applicable to existing machines, has been designed by Mr. Montijn, jun., and is illustrated in the accompanying gravings. Fig. 1 is a side elevation of a punching machine, showing the invention in section, and Fig. 2 a front eleva-



tion. It will be seen that instead of the usual square block, a disc or cam is employed, one half of which is circular, and the other half somewhat flattened. By means of the lever provided with a counterweight, and connected to the disc by a rod as shown in Figs. 1 and 2, this disc can be turned round so that the flattened portion is presented to the sliding block carrying the punch. Thus the motion of the punch can be suspended instantaneously by simply moving the counterweight.

This invention, which has been working with perfect success at the Ironworks of the Netherland Steamboat Company at Fyenoord, is, we think, worth the attention of engineers whose punching machines are not provided with any similar arrangement.

LIME-LIGHTS IN THE CAISSON OF THE EAST RIVER BRIDGE.

The following is taken from the "Journal of the Franklin Institute":—

We can now from personal inspection describe the arrangements by which some fourteen of these lights are kept in constant and successful operation. The plan of these adjustments is, we understand, chiefly due to Mr. Martin, assistant engineer. To secure a steady supply of each gas under constant pressure, two large sheet-iron cylinders, about 21in. in diameter and 6ft. high, are placed upon the top of the caisson, and are connected by iron piping with a water reservoir on the roof of an adjacent building, by which means a hydrostatic column or pressure of some 16 pounds per square inch is made available. These cylinders being filled with water, the gas is let into them from the portable cylinders supplied by the Oxygen Co., in which it is compressed up to a pressure of 225 pounds to the square inch. This displaces the water, forcing it back into the elevated tank and leaving only the tension due to its hydrostatic column of 32ft.

Glass gauges exactly like those used on steam boilers show the level of the water in the stationary cylinders, and thus enable the attendant to regulate the supply of gas in these, so as neither to overcharge them (when the excess would escape through the water-pipes and tank) nor allow them to become empty.

From the upper part of the gas reservoirs or stationary cylinders just described, service pipes are carried down into the caisson, and there distribute to the outer ends and middle points of each chamber where the usual jets and lime holders are permanently attached.

The light afforded by this means is excellent, and if it is possible (as we imagine it must be) to whiten the roof and upper part of the caisson walls, its efficiency would be very largely increased. In looking from one chamber of the caisson into another, where one of the lights was near the doorway but out of view, we were strongly impressed with the idea that daylight was entering through some unexpected opening. The foggy state of the air causes a considerable loss of light, so that at a distance from the burner this is less effective than one might expect. With the number of lights now in use, however, the supply is sufficient, and candles are only required in a few locations sheltered from the direct rays. We feel sure that a whitening of the roof and walls would be of very great service.

It is proposed to let the gas reservoirs descend as the caisson goes down, building around them a coffer-dam, by which means the hydrostatic head will be increased exactly as the air pressure in the chambers is raised, so that a constant difference will be maintained.

The greatest depth to be reached being 40ft., the maximum pressure reqnired, according to the present standard, would be about 36 pounds, and the pressure in the small charged cylinders being 225 ponuds, no difficulty will be found in introducing the gas from them. The pressure now used is, however, largely in excess of what is required, as one or two pounds above that in the caisson would be quite sufficient to secure the steady burning of the lights. In fact, we are sure, from previous experience, that the pressure between the stop-cocks of the jets and the flames is now not more than a small fraction of a pound per square inch in excess of the surrounding compressed air. Were there any object in redncing it, we are quite confident that 25 pound above the atmosphere would be an abundant pressure at the maximum depth of 40ft.

The amount of gas now consumed is about 1,200 cubic feet of each kind per day.

INSTITUTION OF CIVIL ENGINEERS.

DESCRIPTION OF THE COFFERDAMS USED IN THE EXECUTION OF NO. 2 CONTRACT OF THE THAMES EMBANKMENT.

By Mr. Thomas Dawson Ridley, Assoc. Inst. C.E.

The contract upon which these cofferdams were used was let by the Metropolitan Board of Works, in January, 1864, to Mr. A. W. Ritson. It extended from the landing pier at Waterloo bridge to the eastern end of the Temple Gardens, a length of 1,970ft. Mr. J. W. Bazalgette (M. Inst. C.E.), was the Engineer-iu-Chief, aud Mr. Edmund Cooper (M. Inst. C.E.), was the resident engiueer; the author having charge of the works for the contractor.

The breadth reclaimed from the river by this portion of the Embankment varied from 110ft. to 270ft.; the depth of water, when the tide was low, in front of the wall averaged 2ft., and the rise of tide was 18ft. 6in. The borings showed the bed of the river to consist of sand and gravel, resting npon the London clay, at depths varying from 21·58ft. to 27·10ft. under low water mark, whilst the foundation of the wall was in all cases designed to be carried down to a depth of 14ft. under low-water mark. It devolved upon the contractor to design dams to the satisfaction of the engineer, who reserved to himself the power to adopt either caissons, or cofferdams. The author considered that dams of timber and puddle wonld not only be cheaper, bnt could also be more expeditiously constructed, than iron caissons; and having succeeded in obtaining the engineer's sanction to one of the plans which he submitted, the work was begnn. The Temple Pier was the most important work in the contract, and it was therefore requisite to lay its foundation dry as soon as possible. To effect this two short dams, one at each end of the pier, completely enclosing a short length of the river wall, were first begnn. No. 1 was 111ft. 6in. long by 25ft. broad, inside measnre, and No. 2 was of similar breadth bnt a few feet longer. These dams consisted of two rows of piles of whole timbers, averaging 13in. sqnare, with a clear space of 6ft. for pnddle. The piles were from 40ft. to 48ft. in length, having cast iron shoes 70lbs. in weight, and were driven 4ft. into the clay. Cast iron was used in preference to wrought iron for the shoes, as giving, at an equal cost, a much larger base for the timber to rest upon. Where the driving was difficult, shoes having cast iron bases and wrought iron straps were employed. The piles were secnred by three rows of walings of whole timbers, 13in. to 14in. square, through which and passing through the puddle space, at distances of 6ft. 6in. horizontally, were bolts 2½in. in diameter in the lower waling and 2in. in diameter in the middle and upper walings. Cast-iron washers, 9in. in diameter and 2¾in. thick, were used to distribute the pressure over a large surface of the walings. To avoid the difficulty of having to procure a number of long timbers, the piles were in a few cases only of the full length required, and the others, after being driven, had lengthening pieces fixed to them, so as to raise the dam to a height of 4ft. above the high water line. Before proceeding with the construction of these two dams the ground was not dredged, but in all the dams snbsequently constructed, the sand and gravel were cleared off to the level of the clay before the piles were driven. Where the gronnd had not been dredged, great difficulty was experienced in driving the piles, and in the two dams in question one sixth of the whole number pitched, having shown symptoms of failnre, were drawn. In all cases the piles so drawn were observed to have cast their shoes, and their lower extremities were usnally bruised into a mass of tangled shreds. The failure generally occurred when the piles were passing through a bed of compact sand, resting npon coarse open gravel. Beneath the gravel, and resting upon the olay, was a layer of septaria, which offered a serious impediment to the passage of the piles; but when once the clay was reached, the driving was comparatively easy. The space between the piles was dredged to the level of the clay and filled with well tempered puddle. The transverse struts, of which there was a tier to each waling, were of whole timbers, 8ft. apart in the length of the dam.

Simultaneonsly with the construction of these dams, the filling-in of the space behind the Temple Pier was going on, the linc of the dam was being dredged, and the driving of the piles begun. The Temple Pier, 470ft. in length, was irregular in outline, projecting in some parts npwards of 30ft. in advance of the river wall, aud the breadth across the foundation trench in the centre part was 57ft. To avoid the necessity of having to use a large number of struts of such great length, this dam was strengthened by means of buttresses of piles, somewhat similar to those used in the cofferdams constructed for the Grimsby Docks. These buttresses were placed at intervals of 20ft., and were backed up by struts extending across the foundation of the pier. The scantliugs of the timbers and the sizes of the bolts in this dam were similar to those in dams Nos. 1 aud 2, the walings only being a little stouter, averaging 14in. sqnare. Before No. 3 dam was completed, No. 4 dam was begun, and was followed by dams Nos. 5 and 6. In these and in all the dams, except No. 3, the inner row of piles was placed so as to coincide with the riverward face of the concrete in the foundation trench. The piles, walings and bolts of these dams were similar to those in dams Nos. 1, 2 and 3; but the shoring was of a different character. Across the breadth of the wall the struts were all horizontal, and abutted against walings of whole timbers, bolted to pairs of piles, driven into the solid ground behind the foundatiou of the wall. These coupled piles were placed at distances of 18ft. apart from centre to centre, and were further supported by three back struts to each pair, two of which were horizontal and one raking. These struts abntted against piles driven into the slope of the filling material, and backed up with rubble stones. From the lower waling to the bottom of the trench, or to the solid ground, the space in all the dams was filled up with clay, or with a mixture of clay and gravel, to give further stability to the dam, and to assist the lower bolts to resist the pressure of the puddle. Sluices of 4½in. elm plank, and haviug hinged flaps, were inserted in each dam, through the piles and puddle at the level of the lower waling. For dams Nos. 1 and 2, these sluices were 8in. by 8in., internal cross section. In the Temple Pier dam there were two sluices, 3ft. high and 1ft. wide, and for each of the other dams there was one sluice of similar section. In the Temple Pier dam, two iron cylinders, 8ft. in diameter, were sunk to a depth of 4ft. below the lowest level of the foundation, for pump wells, and in each of the other dams one such cylinder was sunk. The volume of water lifted ont of the Temple Pier dam varied from 620 gallons to 1,200 gallons a minute, according as a less or a greater area of the foundation was exposed; but in all the other dams there was much less water to be pumped. As soon as the walls in any of the dams had been raised 6ft. above low water mark, no fnrther pumping was needed, as the water which gathered when the tide was high was passed through the sluices at low water. Mnrray's chain pumps were used in all cases, and were found to be very efficacious. In cofferdams there was usually a freqnent settlement of the puddle, producing channels underneath the bolts and a consequent leakage. In such cases holes were bored, with a 3in. auger, through the inner row of piles, immediately below the tie-bolts, and pellets of clay were driven through these into the puddle until the leakage was subdued.

The quantities of material used in the dams were: In the Temple Pier dam, timber 152 cubic feet, iron 285lbs., and pnddle 9 cubic yards per lineal foot of dam. In the other dams, timber 117 cubic feet, iron 202lbs., and puddle 9 cubic yards per liueal foot of dam. The staging from which the dredging was executed and the piles driven consumed 19·6 cubic feet of timber and 13lbs. of iron per lineal foot. Sissons' and White's steam pile drivers, and those of Appleby Brothers, were used in addition to others wrought by manual labour. The cost of driving was a little under fourpence per foot of the pile when the ground was dredged, but was much higher where the ground was not dredged. The preparation of the piles cost seven-eighths of a penny, and the fixing of the walings and shoring fourpence-halfpenny per cubic foot, exclnsive of the cost of fixing the tie-bolts. In estimating the pressure to be resisted, and the requisite streugth of the dam, the depth of water was taken at 22ft., the piles were assumed to be 12in. square, and the struts 13in. square. The weight of a cnbic foot of the dam was estimated to be 100lbs., aud the breakiug strain of the timber, measured by a load upon the middle of a bar 1ft. long and 1in. square, was taken at 400lbs. The pressure of the water was found to be 15,125lbs., or 6·752 tons per lineal foot of dam. The momentum of the water tending to overthrow the dam was 110,916, whilst the momentum of the dam itself was 83,200. It also appeared that if the dam had been 9·23ft. instead of 8ft. in thickness, it would, considered as a wall, have been, in relation to the pressure of the water, in a condition of equilibrium. The resistance of the piles to fracture at the ground line was calculated to be 47,127lbs. in relation to a force acting at the centre of pressure of the water. If one-third were taken as a safe load, the result was 15,709lbs. to resist a pressure as before stated of 15,125lbs. Disregarding these resistances, and reckoning the whole pressure of one bay to act upon each strut, the thrusts were—on the lower strut 222·82 tons, on the middle strut 77·5 tons, and on the upper strut 47·94 tons. But with every strut resisting an equal pressure the load on each would be 26·14 tons. For the pressure of the puddle on the tie-bolts, the author had no satisfactory data, but he assumed it to be less than that of a similar section of water, and approximately the load upon the tie-bolts was calculated to be, at all events less than the following amounts: On each lower bolt, 2½in. in diameter, 85,250lbs.; on each middle bolt, 2in. in diameter, 54,375lbs.; and on each upper bolt, 2in. in diameter, 37,625lbs. When the dams had served their purpose, it became necessary to clear them away, and before the completion of the whole series the removal of those first constructed had been begun. The piles in front of the ordinary wall were cut off at a level of 3ft. under low water mark, and those in front of the Temple Pier at a level of 7ft. under low water mark. The removal of the piles and puddle was effected in the following manner:—Upon the tops of the piles of each side of the dam half beams were fixed, and upon these rails were laid so as to form a road, upon which the steam cranes and dredging machines to be used in the removal of the puddle could travel, and upon which the pile-cutter could also be moved. These machines were successively placed in position, and the work was begun. For the first 15ft. in depth the puddle was filled into skips, and hoisted by means of steam cranes. Below that depth it was dredged by the machines which had been used for excavating the trench. When the puddle had been cleared away to the requisite depth, the pile-cutter followed and performed its part of the work. This machine consisted of a platform upon a stout frame, resting upon four wheels, which travelled upon the rails before mentioned, and carrying a steam-engine with the requisite machinery for driving a circular-saw, which was fixed at the lower end to an upright spindle, and adjusted to the proper level. The spindle was placed between the two rows of piles, and revolved in guides at the end of moveable arms, so arranged that it would shift to either side of the dam by turning a handle, and by the same motion it could be pressed towards the pile which was being operated upon until it was severed by the saw. Two piles were usually cut off on each side before the machine required to be moved backwards on the rails. When the way was clear for the pile-cutter, and a sufficient length of dam dredged, sixty piles could be cut off in a day, but the excavators could not keep pace with the pile-cutter, and the average number of piles actually cut off did not exceed thirty-six daily. The machine was devised by Mr. Charles Murray, of Loman Street, Southwark, and the author, but the motion which regulated the position of the spindle was the invention of Mr. Murray, alone, and was patented by him. The total cost of the removal of the dams was £1 4s. per lineal foot, made up thus: clearing out puddle, 13s. 6d.; dredging outside of dam, 7s. 6d.; cutting off piles, 3s. per lineal foot.

ON THE WATER SUPPLY OF THE TOWN OF PAISLEY, RENFREWSHIRE.

By Mr. ALEXANDER LESLIE, Assoc. Inst. C,E.

In the year 1835 parliamentary power was obtained to bring in water, for the supply of Paisley, from the districts of Gleniffer and Harelaw, lying to the south of the town, having respectively drainage areas of 624 acres and of 166 acres. The works were executed under the direction of the late Mr. R. Thom, M. Inst. C.E., who made careful experiments, extending over a period of three years, to ascertain the amount of water flowing from the Gleniffer district, by means of which the quantity actually available was found to be 70,354,769 cubic feet per annum, which was equivalent to 31·06in. out of a depth of 46·13in. of rain, over an area of 27,189,063 superficial feet. Of this quantity Mr. Thom awarded one-fourth as compensation to bleach fields.

The works consisted of a reservoir at Harelaw, capable of holding 14,248,000 cubic feet of water, with a conduit leading from thence to Stanely, where there were two reservoirs, one to act as a subsiding pond, the other for holding clear water, with regulating sluices for turning the water into either. The open conduit between Harelaw and Stanely was the principal feeder for the Stanely reservoirs; in its course it intercepted the burns flowing from Gleniffer braes, which was almost all pasture ground. The store reservoir was capable of holding 28,340,000 cubic feet, and the clear water basin 7,194,000 cubic feet. These works provided a supply of 22½ gallons per head for a population of 50,000. In 1855 the works were transferred from the company to the town council, and the claims were settled by arbitration at 6¾ per cent. on capital.

In 1853 new powers were obtained to bring in the water of the Rowbank burn, with a drainage area of 1,220 acres. These powers were however allowed to lapse, and another nearly similar Act was obtained in 1866, under which the present works had been constructed.

Gauges were erected on four streams, and two rain gauges were placed at different levels, to test the amount of water flowing off the drainage area in proportion to the rainfall. The quantity of rain falling on 700 acres, the depth being 64·39in., was equal to 163,614,990 cubic feet, and on 350 acres, the depth of rain being 50·79in., 64,528,695 cubic feet. The average depth of rain over the whole area was 59·86in., or 228,143,685 cubic feet, and subtracting the amount measured by the weirs, 179,662,425 cubic feet, there remained for loss by evaporation, &c., 48,481,360 cubic feet, which was equal to 12·72in. of the rainfall, leaving 51·67in. available for the high ground, and 38·70in. for the low ground. There now remained 170 acres with a rainfall of 38·07in. to be added, which yielded 23,492,997 cubic feet of water per annum, raising the total to 203,155,322 cubic feet per annum.

The pipes were constructed to carry 184 cubic feet per minute, and the compensation water was fixed by the Act of 1866 at 92 cubic feet per minute. Storage was provided for 180 days, or for about 77,000,000 cubic feet. A conduit 6¼ miles long conducted the water to the Stanely filters, whence it was conveyed to Paisley by a 16in. pipe. A branch pipe left the main three miles west of Paisley to supply the towns of Johnstone and Elderslie, and a set of filters and a tank were constructed at Craigenfeoch for filtering the water supplied to those places. Another set of filters and a tank were placed on the high ground to the south of the original reservoirs of Stanely, with a branch pipe leading down to them, to make up any deficiency that might occur in the old works.

The store reservoir erected to impound 77,000,000 cubic feet of water required three embankments, of which the largest was 60ft. deep and 500ft. in length along the top, with slopes of 3 to 1 on the inside, and of 2½ to 1 on the outside. The puddle wall was 8ft. broad at the top, and increased with a batter of 1 in 8 on each side down to the surface of the ground, from which point it diminished to one-half that width, the greatest depth being 62ft. The other two embankments were respectively 230ft. long and 14ft. deep, and 815ft. long and 18ft. deep. The first operation consisted in the formation of a bye-wash channel, to carry the water of the Roivoch burn during the construction of the large bank, as it was from this burn that floods were apprehended, and it now served for conveying impure water on their occurrence. When this was finished, the outlet tunnel was proceeded with, the purpose of which was in the first place to discharge the water which would have accumulated during the construction of the bank, and to receive the two outlet pipes, one of which carried the compensation water and the other the water for the town. The tunnel was 426ft. long, and the interior dimensions were 5ft. 6in. by 5ft. 6in. It had vertical side walls and a semi-circular roof. The whole length of the arch was 15in. thick, of moulded bricks set in cement, with an arch of rubble stone set in mortar over it. At the lower end of the tunnel there was a sluice-house, 10ft. square, with an arched roof, while at the inner end of the tunnel there was a horse-shoe-shaped recess of masonry, in which was placed an iron upstand, or sluice shaft. This recess was 10ft. 9in. long by 5ft. 9in. broad, with walls 2ft. 6in. thick. The upper end of the tunnel, for a length of 17ft., was filled with solid masonry round the outlet pipes, and provision was made in the contract for filling the tunnel with clay round the outside of the pipes, but this had not been necessary. The waste weir was excavated in the solid rock at the south end of the large bank, and was 40ft. long, being at the rate of 1ft. in length for every 30 acres of drainage area.

It was originally intended to strip the entire surface of the inside of the reservoir, as vegetable matter was formerly considered objectionable, but the cost of this led the Commissioners to dispense with it.

The sluice upstand, in the horseshoe recess, was of cast iron 2ft. 6in. in diameter in the inside, and 35ft. high, the metal being ¾ of an inch in thickness. It had four sluices at different levels, each being 17in. square, and fitted with double brass faces. The compensation water was discharged through a separate pipe, with an independent sluice, and the water for the town was conveyed into a cast-iron well, which was constructed with an overflow to take the pressure off the clay pipes, which led from it towards Paisley. The total length of the pipe track from the reservoir to Stanely was 11,126 yards, of which part was of iron pipes, part of clay pipes, and part of masonry aqueducts, the pipes varying in diameter from 16in. to 21in. The trench was excavated 1ft.

wider at the bottom than the exterior diameter of the pipe, and opposite each faucet, there was a clear space of 6in. all round, to permit of the proper jointing of the pipes. The clay pipes were jointed with rope yarn and cement; while the iron pipes, which were for the most part turned and bored; were put together with thin cement. Where clay pipes were used in cuttings above 9ft. deep, a relieving arch of rough rubble was formed over them, which served thoroughly to protect them from crushing. Where the depth of the cutting exceeded 12ft., a masonry aqueduct was substituted for the clay pipes, the sectional area of which was 3ft. by 2ft.

The filters constructed at Craigenfeoch for Johnstone and Elderslie were two in number, each 45ft. by 32ft., and the tank was 50ft by 26ft. and 13ft. deep. The retaining walls were brought up with a void of 4in. in the heart, with two dovetailed recesses to form a tie opposite each other, 12in. by 6in. deep, for every square yard of surface. These voids were filled with clean gravel in layers of 6in. and each layer was grouted with Portland cement. This formed an excellent water-tight wall, the only objection being the cost, which amounted to between 40s. and 50s. a cubic yard. There were two semi-circular wells at the outlet of the filters, with sluices to regulate the head of water over the filters during filtration. The filters had each a 12in. clay pipe along the centre, with 4in. branch pipes open jointed. The filtering material consisted of 2ft. of coarse gravel, 6in. of small gravel, 6in. of slate chippings or shells, 6in. of coarse sand, and lastly 18in. of find sand. The high level filters and tank erected at Stanely were of the following dimensions: three filter beds each 90ft. by 60ft. and a tank 138ft. by 38ft. and 14ft. deep, constructed on the same principle as the others.

The engineer for the works was Mr. James Leslie, M. Inst. C.E. The contractors for the reservoir at Nethertreos were Messrs. Alex. Wilson and Son, and the cost of it, inclusive of sluices and iron work, was £17,433. The same contractors executed the filters for Johnstone and Elderslie, and also the branch pipe from the main aqueduct, at a cost of £7,554. Mr. John Pollock was tho contractor for the pipe track from Rowbank to Stanely, which cost £15,414, and for the Stanely filters which were not yet completed. Messrs. D. Y. Stewart and Co. cast all iron pipes, and also laid that portion between Stanely and Paisley. The total cost of the scheme including purchase of land, way leave, parliamentary and engineering expenses, amounted to £70,000.

BRITISH ASSOCIATION.

ON THE ELECTRO-DEPOSITION OF COPPER AND BRASS.

By W. H. Walenn, F.C.S.

It is intended in this paper to put forward the present condition of the electro-deposition of copper and brass, with sufficient reference to the history of the subject, to make comparatively recent improvements well understood, but treating the process in a practical manner and with reference to some improvements and manipulations that are adopted by the author.

Mr. Alfred Smee, in his "Electro-Metallurgy" dated 1851, gives much attention to the electro-deposition of copper from acid solutions, as well as from neutral salts, and he alludes to potassic cyanide, as a menstruum for dissolving the copper, when articles of iron are to be submitted to the coating process. In mentioning the cyanide electro-coppering solution, Mr. Smee does not notice the fact that hydrogen gas is evolved during the deposition of reguline metal. In reference to the electro-deposition of brass, he has a chapter (length five pages) upon the reduction of alloys, in which he states that zinc and copper have been reduced contemporaneously, and their union afterwards effected by heat. Mr. Smee has evidently not been informed of Professor E. Davy's discoveries in 1830 (see *Phil. Trans.* vol. cxxi. p.p. 147-164) or of the labours of M. de Roulz in 1841, or of Mr. C. Walker in 1845. Certain patented inventions also refer to electro-brassing at this early date, *e.g.*—Fontainemoreau's invention, No. 10,282, A.D. 1844; De la Salzède's process, No. 11,878, A.D. 1847; Fontainemoreau's plan, No. 12,523, A.D. 1849; Russell and Woolrich's discoveries embodied in No. 12,526, A.D. 1849; and Steele's patent, No. 13,216, A.D. 1850.

The point of view, the sphere of thought and the plane of action, from which Mr. Smee was led to regard the electro-deposition of metals was not favourable to the developement and classification of facts that were subsequently recognised. He had only studied in detail neutral and acid solutions, and these in conjunction with the physical laws common to all substances, led him to believe that the evolution of hydrogen gas was an evidence of the existence of the metal in the non-reguline form. Doubtless his admirable researches in relation to his "Chemico-mechanical battery" involving as they did only the employment of acid solutions, tended to confirm his views respecting the influence of the evolution of hydrogen-gas (during electro-deposition) upon the metal obtained. At the present time, however, it is well known that there are solutions, which will deposit reguline metal, during the copious evolution of hydrogen from the cathode, this takes place generally during the electro-deposition of alloys. Many alkaline solutions of single metals also exhibit this peculiarity. It may be that Mr. Smee's views respecting the evolution of hydrogen from the cathode have unduly biassed him in regard to the theoretical views that he puts forward in his chapter upon alloys. These views will not stand the test of experiment and rigorous examination when alkaline solutions are employed. Considerations respecting "the removal of gas" weighed with him, in conjunction with the laws of the conduction of electric force through various media, in the result that he arrived at respecting the electro-deposition of alloys. This result was that alloys might possibly be electro-deposited without the evolution of hydrogen, and by means of an "intense voltaic current." Now that alloys are electro-deposited in a reguline form, commercially, the scientific man of the present day can look back to the enunciations of Smee with great respect, but as incomplete. The ordinary accompaniment of this deposition is a copious evolution of hydrogen gas from the cathode, and although an intense voltaic arrangement is usually employed, it is partially to compensate for the waste induced by the gas evolved, and to save time in the operation of coating. The author's improvements stop the evolution of hydrogen and enable the electro-motive power to be reduced to that of a single Smee's cell.

Mr. Smee's views have been prominently put forward because they present a definite stand point, and because the general knowledge of the subject may be said to date from his able exposition of the positon of the science as it was when his work was written. If first principles are consulted, it will appear that in alkaline solutions, the proneness to evolve hydrogen gas during deposition, arises from the joint action of two causes, one electrical, classified as such by Mr. Smee, the other chemical. The electrical cause is the small quantity of metal in solution in comparison to the electric power employed; this cause can be lessened or removed by using a solution that contains a greater per centage of metal than that usually employed. The chemical cause is the disposition of the metal of the alkali to go to the negative pole along with the heavy metal or metals, and thus, by being electro-deposited for an infinitely small space of time in contact with them, decomposing the water, thereby getting oxidised and setting free the hydrogen as a secondary effect; this cause can be eradicated by providing in excess, a decomposable compound radicle, that will take a certain amount of combined oxygen with it to the cathode, and thus, when decomposed, will enable the hydrogen, that would otherwise be evolved to be oxidised into water.

In the case of brass, a solution containing the cyanides of the component metals dissolved in excess of potassic cyanide, possesses the remarkable property of furnishing the copper and zinc to the cathode in such a form, that, during deposition, thoy unite and form a true alloy; this tendency to form a true alloy is increased by the presence of a salt of ammonium, for in connection with copper (especially as cupric ammonide) the gas that would otherwise be given off is replaced by metal, this result being secondary and, in so far, a chemical reaction. It is usually deemed sufficient to charge the solvent solution (the potassic cyanide and ammoniacal salt solution) with brass by electrolysis, but this will be found on trial to evolve gas, and to be only workable by two Grove's cells. The author finds that it is practically serviceable to add to a solution that is charged with not less than two ounces of brass per gallon, as much of the metallic cyanides as it will take up, and then it will probably take still more of the copper and zinc oxides respectively. Should this treatment not perfectly prevent the evolution of gas, the cupric ammonide is added—about two or three ounces per gallon. The cupric ammonide may possibly carry the combined oxygen to the cathode:—

At the cathode before chemical reaction.	At the cathode after chemical reaction.
$Cu_2O\ 4NH_3 + 4H_2O$	$= Cu_2 + 4\ (NH_3) + 5\ (H_2O)$
Cupric ammonide. Hydrogen.	Copper ammonia. Water

Malaguti and Sarzeau's formula for cupric ammonide being used. That is to say, before decomposition or chemical reaction takes place, the whole of the cupric ammonide, together with the eliminated hydrogen goes to the cathode; after the decomposition or chemical reaction has taken place, metallic copper is deposited, ammonia is in solution, and water is formed. In treating the ordinary cyanide copper solution for the prevention of the evolution of hydrogen, the zinc cyanides and oxides, mentioned in the instance of the brass solution, are left out. When the evolution of hydrogen gas has been stopped by the means above set forth, a single Smee's cell is sufficient to deposit the alloy, thus showing, that an intense voltaic current is not absolutely necessary, but that the process requires a certain condition of solution to give a perfect result.

The author prefers to use a menstruum containing potassic cyanide and neutral ammonium tartrate in equal parts and dissolved in five times their weight of water, to dissolve the brass in This is then treated, as explained above, to prevent the evolution of hydrogen. This solution is employed in conjunction with heat, and a single Maynooth cell or a magneto-electric machine of suitable power. It has been found, with some electro-brassing solutions, difficult, to deposit continuously a given quality of brass; with this solution the regulation of the proportions of copper and zinc in the alloy is made by altering the heat accordingly. If the solution is kept uniform, as shown by a ready test, it is very easy to deposit a given alloy at all times.

Before entering upon some practical points connected with the electro-deposition of copper and brass, it will be well to remark that acid solutions furnish a spreading deposit matted together, resembling the spreading of mortar by a trowel; whereas, alkaline solutions furnish a deposit standing up from the receiving surface at right angles thereto, as the hairs of a brush stand out from the brush itself. In coating wrought or cast-iron work, it is often advisable to coat with copper prior to electro-brassing; the alkaline bath should be employed above the temperature of the air, sometimes 160° Fahrenheit; this method of working promotes the contact of the coating. The article should be well cleaned, so as to have a metallic appearance, with a pickle of weak sulphuric acid, scrubbed with sharp sand, washed, scrubbed with a portion of the depositing solution, and then placed in the depositing trough. The electrical connections may then be made and the coating allowed to form for two hours or more. When a sufficient thickness has been obtained the article is washed, and dried in hot mahogany sawdust. The "tarnishing" of the coating increases its beauty and does not impair the article, for the tarnish is not corrosive rust like the oxide of iron, but is a protective film. Two hours coating will protect from rust in ordinary indoor work, but the best protection from rust (and this is serviceable even in damp air) is to give two hours coating in an alkaline bath and then let the article remain all night in an ordinary acid sulphate of copper bath; this plan utilises the matted coating as well as the vertical deposit. If desired, a brass coating may be given over the last-mentioned copper coating. By suitable mechanical arrangements, the articles in the acid bath and the dissolving plates therein, may be moved —preferably by a to-and-fro movement—during deposition. This treatment shortens the time of the deposit, and makes it (the deposit) uniform. The roller which is exhibited was treated in this manner; it now weighs 125lbs. having 29lbs. weight of deposit upon it, the coating being 3-16ths of an inch thick. The other works show various applications of electro-coppering and electro-brassing. The price of the above-mentioned, when a single Maynooth cell is used, is 2s. 6d. per lb. of metal deposited. When a magneto-electric machine is employed the cost is much reduced, viz., to 1s. 6d. per lb. of metal deposited.

The coating given by means of the improvements introduced by the author is superior to that given by any other known process; these remarks apply to the economy of the question, also to the solidity, perfection and beauty of the result. In consequence of the non-evolution of hydrogen, the adhesion of the coating to the underneath iron or other metal, is ensured, also the coating is solid and compact instead of being more or less detached and spongy, as it is when hydrogen gas is allowed to be eliminated. The ammonium tartrate solution used for electro-brassing as well as the methods of preventing the evolution of hydrogen during deposition, that are mentioned herein, form a part of the subject matter of specifications No. 1540 (A.D. 1857), and No. 3,930 (A.D. 1868).

The uses to which electro-brassing may be applied have yet to be greatly developed, among the rest may be mentioned: the prevention of rust; the giving of an improved printing surface to type and electrotypes; coating the poles of electro-magnets for the prevention of the "residual charge" therein; covering rams, plungers, piston-rods, rollers, &c., with an adhesive and endurable coating; also lining cylinders, pumps and iron vessels with copper or brass. The application of the processes that have been described to many purposes of ordinary life, such as railings, architectural ornaments, &c., will exemplify the good results to be obtained by the union of the strength of iron with the beauty of copper or brass.

ELECTRIC TIME SIGNALS.

By S. Alfred Varley, Assoc. Inst. C.E.

The progress made in the application of electricity to time signalling has been brought under the consideration of this section at more than one meeting of the Association. In the year 1850, the Astronomer-Royal applied electricity to time signalling. In 1854, the British Association met at Liverpool, and in that same year a time ball acting in sympathy with the Greenwich Observatory ball was erected in Liverpool. It so happened, the author at that period had the charge of the telegraphs belonging to the Electric Telegraph Company, in the Liverpool district, under Mr. Culley, now the engineer-in-chief of the postal telegraphs, and the immediate superintendence of the Liverpool time ball fell to his charge. The discharging a time ball weighing 4 cwt., by electricity, from a distance of over 200 miles, was the greatest feat of its kind up to that time. The circumstance of the British Association again meeting at Liverpool has suggested to the author that a description of the time ball erected at Port Elizabeth, for the benefit of the shipping in Algoa Bay, and which is daily discharged from the Royal Observatory in Cape Town, a distance of 500 miles, would be of interest to the Association. This time ball is discharged by a through current from Cape Town; that is to say, there is no relay or intermediate apparatus between the Observatory and Port Elizabeth, the trigger being discharged by the galvanic battery at the Observatory. There are some points of interest connected with the Liverpool time ball which have not been published, and a brief description of the signal may be useful; but the subject of time balls having been before this Association on former occasions, it is scarcely necessary to enter into lenghty details. The Liverpool time ball, which was made of zinc, and weighed 4 cwt., was attached to a strong iron rack, on the lower end of which there was a piston, and when the ball was discharged, after it had passed through a clear space of 2ft., the piston entered a cylinder compressing the air in its descent; the compressed air formed a cushion to receive the ball, and was allowed to escape through a tap fixed into the lower portion of the cylinder; this enabled the rate at which the air escaped, and the rate of the final descent of the ball to be regulated. The ball was raised by means of a pinion working in the rack, and when wound up, and the pinion thrown out of gear, the piston rested upon a strong steel detent, the other end of which rested against a friction roller fitted into one end of a rectangular lever. The pressure exerted on the rectangular lever was entirely vertical. A second lever pressed against the underside of the lever, and on this second lever a hammer impinged. Attached to the axle upon which the hammer worked there was a lever having a friction roller which rested against a horizontal plane of polished steel fixed to a vertical lever, which worked on a pivot at its lower end. A long light lever, mounted upon a delicate axle, and having a curved arm projecting on the other side of the axle, rested upon the top of a lever, to the lower end of which was attached a soft iron armature. The armature was retained a short distance from the poles of an electro-magnet by means of a delicate spring, and when the electro-magnet was rendered active by closing the electric circuit through it, the armature was attracted, the lever fell, knocking away the vertical lever, liberating the hammer, the impact of which on the lever, acted upon the rectangular lever, released the detent, liberating the ball which fell by its own gravity. The hammer and the other levers were actuated by springs to make their action more rapid. The trigger and the general arrangements of the time ball were carried out under the superintendence of Mr. Latimer Clark. The electrical arrangements were as follows: The Greenwich Observatory clock closed an electric circuit at 1 p.m. This current discharged a time ball on the top of the telegraph office in the Strand, and entered the earth at the chief London telegraph office after passing through an apparatus designed by Mr. Culley, and termed the automaton, as it automatically closed several electric circuits, and relaid time currents from batteries in the London office to Liverpool, Manchester, and other chief towns. Shortly after the time ball at Liverpool had been got to work it was thought advisable to make some alterations in the trigger, and it was sent to Manchester to be altered, but after this had been done it was lost in its transit from Manchester to Liverpool, and a new one had to be constructed. This second trigger was made at the Telegraph Company's stores in Manchester, under Mr. Culley's superintendence, and some improvements were effected in its construction. The only thing which had to be done at Liverpool was to wind up the ball, adjust the trigger, and wait for the time current which discharged the ball at one o'clock. The author soon felt it was very desirable there should be some check by which the Electric Telegraph Company could ascertain that the apparatus in their offices was working correctly, and he suggested arrangements for effecting this, and he also proposed a means of measuring the loss of time between receiving the Greenwich current in London and the falling of the time ball at Liverpool, for there necessarily was a loss of time, and it was desirable to ascertain the amount.

The elements of loss of time were:—1. The automaton occupied a small interval in closing the circuits after the current had arrived from Greenwich; 2. The time current was sent to Liverpool by an underground circuit, and an appreciable interval of time elapsed between the current leaving London and arriving at Liverpool. 3. The trigger occupied time, discharging one lever after another.

The arrangements suggested and carried out were:—1. The hammer of the trigger, after liberating the detent upon which the ball hung, was made to divide the circuit so that electrical communication was broken by the apparatus itself immediately after its discharge, and at the same time that the circuit was divided the trigger hammer connected batteries at Liverpool on to a second wire, and sent a return current to London. The Liverpool time wire passes through the Manchester Telegraph Office, to which a time current was also sent at one o'clock, and advantage was taken of this to obtain an additional cheek. The diagram shows the arrangements which were adopted. Two galvanometers were placed in the chief telegraph office in London side by side ; one of these was placed in the Greenwich time wire, the other circuit from Liverpool. In the Manchester office two galvanometers side by side were placed, one in the circuit of the Liverpool time wire, the other in the Manchester time wire. In Liverpool the time wire was also connectcd throngh a galvanometer as well as the trigger. An observer in London noted the receipt of the Greenwich current, and the interval of time elapsing before receiving the return current from Liverpool. An observer at Manchester noticed the simultaneous arrival of the time currents on the Manchester and Liverpool circuits, and the rapid cessation of the current on the Liverpool circuit conseqnent upon the dividing of the circuit by the trigger. An observer at Liverpool also noticed the reception of the current, and its rapid cessation, indicating there was no hanging fire on the part of the apparatus at Liverpool. In this way a very complete check was obtained, and the galvanometers in the Liverpool circuit at Manchester and Liverpool in practice only swung over a space of 15 or 20 degrees, instead of being permanently deflected which they would have been if the apparatus had hung fire. The interval elapsing between the receipt of the current from Greenwich in London and the discharge of the ball in Liverpool was $\frac{11}{20}$th of a second. Of this time, $\frac{5}{20}$ths of a second were occupied by the current travelling through the underground wire between London and Liverpool ; $\frac{2}{20}$ths of a fraction were consumed in the automaton, and $\frac{4}{20}$ths + a friction in the trigger. The author constructed an electric chronograph to enable him to measurc small intervals of time, making use of a Bain's telegraph machine for the purpose. A Bain's teregraph consists of a train of wheels regulated by a fly, and driven by a weight. A metal drum connected with the train communicates motion to a ribbon of paper preparcd with ferro-cyanide of potassium and nitrate of ammonia. When the machine was started the ribbon of paper passed over the drum at the rate of 6ft. per second. A piece of fine steel wire insulated from the drum pressed lightly upon the prepared paper, and the circuit was closed through the stcel wire, the prepared paper, and the metal drnm. When the circuit was closed the ferro-cyanide of potassium was decomposed, the cyanogen combining with the wire forming prussian-blue, and as the paper was in motion a blne line was formed on it as long as the circuit was closed. This machine gave the means of measuring time in space, and the way in which the author measured the loss of time in the trigger, for instance, was as follows ; He placed the Bain's machine in circuit with the trigger, making the trigger to divide the circuit after discharge, as already described. The machine was started by the pendulum of a regulator, or the seconds-hand of a watch, and the electric circuit was closed by means of a contact maker, The electric circuit remained closed until the circuit was divided by the trigger recording a blue line on the paper. The paper was usually allowed to run until one minute was completed, and then stopped. The length of paper run out was then accurately measured, and also the length of the blue line, and from these two measurements the interval of time could be exactly determined. In the year 1859 Sir Thomas Maclear, the Astronomer-Royal of the Cape of Good Hope, inspected the electrical time signals in this country with a view to erecting time balls in connexion with the Royal Observatory at Cape Town, and he remarked the greater rapidity of action of the Liverpool trigger, and this led to the author afterwards designing and constructing at different times two triggers for use in the Cape. Both these triggers discharged more rapidly than the Liverpool trigger. In September, 1864, the author was requested to constrnct a trigger for discharging a time ball to be erected at Port Elizabeth. The author considered the intervention of any relay or secondary apparatus to be objectionable. He therefore determined, if possible, to construct the trigger sensitive enongh to be discharged by the batteries in the Capt Town Observatory, and in its construction he adopted a modification of a principle first introduced by Professor Hughes in his printing telegraph, described at the Newcastle meeting. The trigger was constructed with a soft iron armature, rendered magnetic by induction from a powerful compound bar-magnet, and strongly attracted the soft iron cores of an electro-magnet. A spiral spring attached to this armature was so adjnsted that it nearly overcame the magnetic attraction induced by the bar-magnet,. The time current polarised the electro-magnet in the opposite direction to that indnced by the bar-magnets ; and as the attraction between the armature and the soft iron cores was already almost overcome by the spiral spring a very small amount of polarisation in the opposite direction was necessary to release the armature which was rapidly pulled away by the spiral spring, and the trigger discharged. There were some other alterations made in the general mechanical construction of this trigger, but they may be regarded as matters of detail. The rapidity of discharge was very great —1-20th part of a second only elapsed between the arrival of the time current and the falling of the ball. From a report in the Port Elizabeth paper of Angust 29, 1865, giving an account of the inauguration of this time signal, and forwarded to the author by Sir Thomas Maclear, it appears that the time elapsing between the time current leaving the Observatory at Capt Town and the receipt at Cape Town of the signal announcing the falling of the ball is only 1-15th part of a second. The time which elapsed between the Greenwich current reaching London and the falling of the ball at Liverpool was 11-20th of a second. In other words, the Algoa ball is discharged a distance of 500 miles in less than 1-7th of the time of that of the Liverpool ball. What is being daily done in the Cape can, however, be best summed up by a short qnotation from a letter the author received from Sir Thomas Maclear giving an account of the successful inauguration of this time signal.

After detailing the general arrangements, Sir Thomas Maclear goes on to state : "A few tentative signals having proved satisfactory, the 'preface' was issued from the Observatory at ten minutes before one o'clock, and at the instant of one o'clock the Observatory time ball clock closed the circuit discharging the Observatory ball, the Simon's town ball, 24 miles distant, the Cape Town time gun 3 miles distant, and the Port Elizabeth ball, distant 500 miles !"

ON THE THERMODYNAMIC ACCELERATION AND RETARDATION OF STREAMS.

By W. J. Macquorn Rankine, C.E., LL.D., F.R.SS.L. & E.

1. General Principle stated.—The object of this paper is to state in a more general and comprehensivc form than has hitherto been done to my knowledge, a thermodynamic and hydrodynamic principle of which many particular cases are well known and understood. That principle may be stated as follows :—In a steady stream of any fluid, the abstraction of heat at and near places of minimum pressure, and the addition of heat at and near places of maximum pressure tend to produce acceleration ; the addition of heat at and near places of minimum pressure, and the abstraction of heat at and near places of maximum pressure tend to produce retardation ; and in a circulating stream the quantity of energy of flow gained or lost in each complete circuit is equal to the qnantity of energy lost or gained in the form of heat ; and in the absence of friction, the ratios borno by that qnantity to the heat added and the heat abstracted (of which it is the difference) are regulated by the absolute temperatures at which heat is added and abstracted, agreeably to the second law of thermodynamics.

2. Equation of the Flow of a steady Stream without Friction.—Let a steady stream of any fluid, whether liquid, vaporous, or gaseons, flow in a suitable smooth passage or channel without friction. At a given point in the stream let v be the velocity, U the potential energy of attractive forces exerted on unity of mass of the fluid, s the bulkiness, or volume of unity of mass, and p the pressure. Then by a well-known equation of hydrodynamics we have

$$vdv + d\mathrm{U} + sdp = 0, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

or, in the integral form,

$$\frac{v^2}{2} + \mathrm{U} + \int sdp = \text{constant}; \quad . \quad . \quad . \quad . \quad (1\mathrm{A})$$

that is to say, what each. unit of mass gains in energy of flow (denoted by $\frac{v^2}{2}$) it loses in energy of head, as the qnantity $\mathrm{U} + \int sdp$ may be called. When the attractive force considered is gravitation near the earth's surface, we have $\mathrm{U} = gz$, z being the height above some fixed horizontal surface.

3. Thermodynamic Acceleration and Retardation.—Let it be supposed that a stream comes from a place where the pressure is p_1, and the potential energy of attraction U_1, flows through a place where the pressure is p_0, and the potential energy of attraction U_0, and finally arrives at a place where the quantities p and U have their original valnes p_1 and U_1. Let the fluid be in the condition called *adiabatic*—that is, let it neither receive nor give out heat. Then the relation between p and s is defined by the constancy of the *thermodynamic function*

$$\phi = \mathrm{J}c \text{ hyp. log } \tau + \chi(\tau) + \int \frac{dp}{d\tau} ds ; \quad . \quad . \quad . \quad . \quad (2)$$

in which J is the dynamical equivalent of a unit of heat, c the real specific heat of the fluid, τ the absolnte temperature, $\chi(\tau)$ a function of τ which is null for substances capable of approximating indefinitely to thc perfectly gaseous state, and will be omitted throughout the rest of this paper ; and in the integral $\frac{dp}{d\tau}$ is taken on the supposition that is constant. Then at the place where the pressure is p_0, the energy of flow in each unit of mass is expressed by

$$\frac{v_0^2}{2} = \frac{v_1^2}{2} + U_1 - U_0 + \int_{p_0}^{p_1} s dp, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

the integral being taken subject to the condition that the thermodynamic function ϕ has a certain constant value.

By the time that the stream has arrived at the place where U and p return to their original values, v also has returned to its original value v_1; and here there is no thermodynamic acceleration or retardation.

But next suppose that at the place where the pressure is p_0 each unit of mass has a certain quantity of heat either added to or abstracted from it, so as to change the thermodynamic function from ϕ to ϕ'. That quantity of heat is expressed in dynamical units by

$$\int_{\phi}^{\phi'} \tau_0 d\phi. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Let the return to the original pressure take place with this altered value of the thermodynamic function. Then throughout this second division of the stream each value p of the pressure will have corresponding to it a value s' of the bulkiness suited to the new value of the thermodynamic function, and different from the value s corresponding to the same pressure in the first division of the stream. The relation between the change in the value of ϕ and the change in the values of s is given by the equation

$$\phi - \phi' = Jc \text{ hyp. log} \frac{\tau}{\tau'} + \int_{s'}^{s} \frac{dp}{d\tau} ds \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

At the end of the process the stream, on arriving at the second place where the pressure is p_1, will now no longer return to the same velocity, but its energy of flow will be

$$\frac{v_2^2}{2} = \frac{v_0}{2} - U_1 + U_0 - \int_{p_0}^{p_1} s'dp = \frac{v_1^2}{2} + \int_{p_0}^{p_1} (s - s')\, dp, \quad . \quad (6)$$

and there will have been on the whole a change of energy of flow to the following amount,

$$\frac{v_2^2 - v_1^2}{2} = \int_{p_0}^{p_1} (s - s')\, dp; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

which is a gain or a loss, corresponding to an acceleration or a retardation, according as it is positive or negative, its sign being the same with that of the product $(p_1 - p_0)\ (\phi - \phi')$.

4. CIRCULATING STREAM.—Let the place at which the stream arrives and where the pressure is p_1 be the same with that from which it sets out; and on the return of each particle to that place let a quantity of heat be abstracted or added, as the case may be, so as to restore the thermodynamic function to its original value ϕ. That quantity of heat is expressed by

$$\int_{\phi'} \tau_1 d\phi. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Then in the course of each complete circuit made by a unit of mass of the fluid in that stream there is a change in the energy of flow to the amount expressed by equation (7); and according, as that change is a gain or loss, there is on the whole a disappearance or a production of heat to an equivalent amount, expressed by

$$\int_{\phi'}^{\phi} (\tau_1 - \tau_0)\, d\phi = \int_{p_0}^{p_1} (s - s')\, dp. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

5. EXAMPLES.—Amongst particular cases of the thermodynamic acceleration and retardation of streams the following may be specified. Acceleration by the addition of heat at and near a place of maximum pressure:—the draught of a furnace; and the production of disturbances in the atmosphere in regions where the ground is hotter than the air. Retardation by the abstraction of heat at and near a place of maximum pressure:—the dying away of atmospheric disturbances in regions where the ground is colder than the air. Acceleration by the abstraction of heat at and near a place of minimum pressure:—the injector for feeding boilers, in which a jet of steam, being liquefied by the abstraction of heat, is enabled not only to force its way back into the boiler, but to sweep a current of additional water along with it; also, to a certain extent, the ejector-condenser.

6. RETARDATION BY CONDUCTION.—The conduction of heat from the parts of a stream where the pressure and temperature are highest to the parts of the same stream where the pressure and temperature are lowest, produces, according to the foregoing principles, a gradual and permanent retardation of the stream, independently of the agency of friction; and this is accompanied by the production of heat to an amount equivalent to the lost energy of flow.

UPON THE POLICY AND PROVISIONS OF A PATENT LAW.

By R. M. PANKHURST, LL.D., Barrister-at-Law.

The objections to the policy of a patent law may be distinguished into two classes: There are, firstly, those who insist that any protection at all to inventions is essentially vicious and wrong. There are, secondly, those who, while admitting that some protection to inventions is right and desirable, deny that it ought to be in the nature of a legal protection. With regard to these objections, it seems expedient at the outset to offer the following definitions:—In the first place, an invention, considered with reference to its being made the subject of legal protection, may be defined to be an application of knowledge, and in general of the laws of nature, to the materials of nature expressed in the form of a new and useful process. Therefore, an invention does not consist in the knowledge applied nor in the materials used, but in the combination of the one and the other into a system of means, of which system the distinguishing characteristics are novelty and utility. Therefore, further, an invention does not consist in the product arising from the use of the system of means of the process. An invention, in short, consists of means to an end. A patent right, with reference to the same purpose of giving legal protection to inventions, may be defined to be the creation of a limited right of property in a new and useful process. This definition presents two points: The fact of the creation of a right of property, and the extent of the right so created. Indeed, objections have been made to both these points. It is by some distinctly denied that a right of property in inventions ought to exist. But this right of property in the limited form of a patent has as good a right to exist as any, for it rests finally upon the same foundation, viz., improvement by labour. In fact, the only real difference between property in inventions and other property consists in the greater difficulty in the case of the former as compared with the latter of the definition and protection of the right. It must certainly be admitted that it is more difficult to define and protect property in inventions than property in general. But, surely, the fact of such difficulty is not sufficient reason for not creating a right of property. There is far more difficulty in defining and protecting the forms of property known as rights to light and air; but that has not been found sufficient ground for not giving those interests the character of legal rights. Indeed, as society becomes more highly organised, the more clearly and expressly do these rights become parts of positive law. The same principle of social development increases the necessity for patents. Again, in point of principle there is no difference between copyright and patent right, except the difference of case and difficulty of definition and protection. Therefore the analogy of the position may be presented thus: Patent right is to copyright what rights of light and air are to the ordinary rights of property. Now every legal right is an evil, for it arises from the imposition of obligation and restraint on others. The basis of a right is a duty cast upon others. When, however, the creation of a legal right is expedient, it is always the preference of a lesser evil to a greater. In the case of all rights in themselves proper, the evil of limitation of liberty is less than the evil of unlimited liberty. What, then, are the considerations of gain which should induce the creation of a right of property in inventions? They are principally the following:—(1) That inventions may be made more rapidly and in greater number. (2) That inventions may become promptly and thoroughly perfected. (3) That inventions may be more speedily and fully disclosed. (4) That inventions may be more energetically and successfully introduced into common use. (5) That invention may finally, after the legal right in them has been duly determined, become the common property of society. It is submitted with confidence that these are sufficient reasons. It is sometimes objected that the inventor has no natural right to the exclusive use of his invention. Granted, but then within the limits of positive law such things as natural rights are unknown. Indeed, the expression "natural right" is a mere metaphor. Legal rights derive their origin solely from the force of legislation. The considerations just presented in regard of the purpose of increasing the number of inventions are not assertions of natural right on the part of inventors, they are simply reasons why the claims of the inventor to his invention should be acknowledged by giving him a right of property of a limited character in his invention. The whole essence of the case lies here:—Is it the best way to promote invention and improve manufactures to give the inventor a limited right of property in his invention? If so, then these objects are the reasons, the causes of the creation of the right of property; but the source of the right itself is the act of the legislature. A prominent objection of an important character must be noticed *in limine*. To many it is thought a sufficient answer to the advocates of a patent law to say that it is a monopoly. Two classes of objectors use the same argument, bnt mean by it two distinct and different things. In the former class are those who use the argument of a monopoly to condemn a patent law, because they think that inventors are not entitled to any legal protection at all; while in the latter class those who, though willing that inventors shonld have protection, maintain that the mode of a patent law is objectionable, on the gronnd of the same evils as those which lie against the existence of a monopoly properly so called. But a patent right is not a monopoly. A monopoly is a protection to an existing mode of manufacture or form of industry. Bnt a patent right is a protection to a new mode of manufacture or form of industry. In order that new modes of manufacture may be discovered, matured, pressed into general nse, and finally added to the common property of the nation, legislation, as the most expedient means of effecting this end, gives a limited right of property to the inventors of such new modes. A monopoly is a means of keeping in the possession of a few, and injuriously limiting the value of, existing property; while a patent right relates to something before unknown being then first called into existence, and supplied for the use of man. With regard to the policy of a patent law, something ought to be said about the position of those who admit that an inventor is entitled to some protection, who indeed confess that an inventor is a creditor of the nation, and is, therefore, entitled to be compensated by the nation. Those holding this view, and notably Mr. Macfie, present various plans for recognising the claims of inventors. The plan most frequently contended for is a system of governmental payments of money, based upon a valuation. Against this scheme may be urged the objectino that, though it might very appropriately form a complement to a patent law. it can never be fitly regarded as a substitute for a patent law. A patent law, while giving an adequate stimulus to invention, also secures that during the period that the right of property exists it shall be so limited by the terms of its creation as to give the minimum of interference with the freedom of manufacture with the maximum of advantage to the inventor and the pnblic. Having, then, considered a patent from the point of view of a limited right of property, two further points arise; Firstly, how is the right created; and secondly, how are the nature, extent, and limitations of the right determined? The right of property in an invention arises and springs in point of source from a grant of letters patent. The right, therefore, is purely a creature of law, of positive law. The nature, extent, and limitations of the right of property are determined by the specification. The specification describes and defines the invention as to its nature and extent. By means of the specification are determined the questions of utility, novelty, and invasion. Therefore the most important thing to observe is that the nature and limits of an inventor's right of property in an invention are determined by the construction of a written document. This is a point that goes right to the root of the essential difficulties of a patent law. Issues in patent causes are principally questions of construotion. It must be obvious, then, that the most necessary and essential thing is to take care that the instrument upon the true construction of whioh the decision of those issues depends should be framed with the utmost possible care and circumspection. Now a specification consists of two principal parts: the common language used, and the technical phraseology employed. The distribution of the specification into these two divisions presents an important consideration with regard to the mode of trial in patent causes, which will hereafter be adverted to more fully. Further, the fact that patent law qnestions are principally questions of the construction of a written instrument has a very essential bearing upon the mode of grant and procedure of administration. With regard to the existing law, both as to its constitution and working, no doubt many of the evils and grievances complained of are to a large extent well founded, but they are neither so many nor so great as to induce donbt as to either the policy of the law itself or the possibility of giving fit expression to that policy through the medium of an appropriate legal system. The practical evils may be reduced to three principal heads: (1) The indiscriminate granting of patents. (2) The want of accuracy in defining the nature and limit of the rights secured by the patent. (3) The cost, vexation, and unsatisfactory character of the trials in patent causes. These three serious grievances import: First, that rights of property are granted in respect of what purport to be inventions, but which are not really so; secondly, that rights of property in inventions are created in terms and under definitions inaccurate and defective; and finally, that the mode of determining the nature of the rights of property in inventions, and the fact of their invasion, is exceedingly difficult, costly, and cnmbrous.

The first is a case of defective machinery for inquiry before grant; the second is a case, for the most part, of want of care and skill in definition and expression in the terms of the grant; and the last is partly the result of the second, and partly a consequence of defective procedure in respect of administration. With regard to the proposed remedies, the first remark proper to be made and firmly insisted upon is that the defects and abuses complained of arise in respect of a law, the existing law, which not only has not been fully and fairly worked within the limits of its power, bnt has not, strange to say, been carefully and duly applied precisely at those points where its provisions were originally framed, and are, in fact, most calculated to repress and remove those very evils and mischief. Therefore the remedies now presented are of a twofold character: suggestions for the efficient working of the existing law and the introduction of additional provisions in regard both of constitution and of administration. The proposed remedies may be classified as follows: (1) Conditions precedent to the granting of patents. (2) Provisions directed to secure accuracy of description and definition. (3) Conditions precedent to litigation. (4) Provisions in regard to the mode of trying patent causes. It is intended to deal with these points in their order. (1) As to conditions precedent to the granting of patents. Here it is submitted that the grant of a patent shonld not be of course, but only after examination, and this involves two things, the nature and extent of such examination. The object of an examination is first and principally the provision of information, both to the inventor and the Crown, so as to secure as far as possible that only real inventions shall be patented, and, in the next place, to give due attention at the earliest point to the all-important questions of desoription and definition. With this view it is insisted that the present functions of the law officers of the Crown, which in the very nature of the case they cannot adequately perform, and which, in fact, are not really performed at all, should be either abolished or essentially modified. It is therefore proposed that the grant of a patent should be preceded by an examination of competent examining officers in respect of tho novelty of the invention, of its fitness to become the subject of a patent, and of the sufficiency of the provisional specification.

With regard to the extent of the examination, it seems quite clear that it ought not to go the utility of the invention, that being a point in which experience and results should alone be allowed to testify. To give the power to sit in jndgment on the question of utility prior to the grant of a patent would injuriously limit invention and impede progress. The result of the examination should be expressed in the from of a report. If the report is favourable to the patent the grant of a patent should then at once be made; bnt if unfavourable the applicant should, in addition to his right to be heard before the examining officers, have a right to be heard by way of appeal from the report to the law officers.

If their decision be adverse the applicant should not be denied his patent, but should have it granted at his peril, upon the condition that the report be recorded, and that in the event of fnture litigation the fact of the existence of an adverse report should have effect in respect either of security for costs or payment thereof, or both. In cases of opposition to the grant, the objections shonld be dealt with in the first instance before the examining officers, with the same right of appeal to the law officers. In this way, therefore, points of inquiry and matters preliminary would be referred to a competent tribunal; while points of construction and matters judicial would be relegated to a fit tribunal of the character of a *quasi* Court of Appeal.

The report and the result of the examination would have these effects:—Of information, of warning, and of accurate statement in regard of the provisional specification. Tho whole of the suggestions as to examination would be effected by a mere extension of machinery, with the exception of turning the functions of the law officers into a kind of Court of Appeal, functions certainly more consonant with their position, and for which they would be manifestly more efficient. (2) As to the provisions directed to secure accuracy of description and definition the specification is the patentee's charter; it ascertains and measures his rights. It is most important. therefore, that this document should receive the utmost care and attention. It is submitted that the specification should be reported upon by competent officers, with a view to obtain a precise definition and description of the invention, including an accordance and conformity with the provisional specification. If the report suggests amendments which the applicant declines to make, a right of appeal to the law officers should be given. The decisions of the law officers may either be made final, and amendment in conformity therewith enforced, or it might be provided that in the event of an adverse decision, if the applicant still declines to amend as suggested, the report should be recorded, and the fact of its existence have effect with reference to costs in the event of litigation. Of course, in respect of all proceedings by the examining officers, the applicant should have full power to appear and be heard. Hardly any amount of attention and anxiety can be said to be too much to secure that the specification be framed accurately, and sufficiently describe and define the invention; for care applied here would prevent the existence and influence of a thousand mischiefs, the evil consequence of which cannot be averted by any care, however great, exerted afterwards. It is not too mnch to say that by far the largest proportions of the outcry against patents would be silenced by proper provision for accuracy in the language and terms of the specification. (3) Conditions precedent to litigation. The object of imposing such conditions is to invert the usual order of procedure. It is certainly desirable to determine judicially what the right is, before considering whether it has been invalid. All the best opinion and experience confirm this conclusion. From this point of view it is submitted that prior to the institution of proceedings for the infringement of a patent the report of an examining officer should be obtained based upon the statement of the applicant as to the precise nature and extent of the alleged infringement. If the report be adverse, then the applicant should still be allowed to proceed, but upon condition that the statement and report be recorded, and the fact of their existence have effect in relation to the question of costs. These provisions would always aid the inventor by giving him an opportunity of precisely realising his position, and would protect the public in respect of groundless litigation. (4) Provisions in regard to the trial of patent causes. The essential difficulties of the patent law are difficulties of construction. The document forming the basis of all the proceedings is the specification. Now the interpretation of documents is essentially a judicial function. This circumstance ought to govern the principle upon and the procedure by which the trial of patent causes should rest and be conducted. The construction of a specification is for the court alone; but, in view of the nature of the technical language employed, it is desirable that the court should be assisted in its action by authority competent to inform it of the true meaning of such language. It is therefore submitted that the trial of patent causes should be conducted before a judge sitting with assessors. The procedure of the assistance of assessors works well in the parallel case of the Admiralty Courts. It is practically adopted in the analogous care of the Judicial Committee of the Privy Council, which is the court of final appeal in matters relating to the doctrine and discipline of the Church of England. In such cases the articles and formularies are to receive a true construction in point of law according to the legal rules for the interpretation of statutes and written instruments. These articles and formularies contain technical phraseology, but any assistance that the court may need as to the meaning of such phraseology is rendered y the presence and aid of the bishops.

With regard to the defence in patent cases, the action of the examining officers will be called into play in compelling the defendant to state his objections with precision, subject to appeal to the courts. By this means the total amount of litigation will be lessened, and the actual issues finally brought to trial will be reduced to a minimum. These suggestions are, it will be noticed, directed to the applications of the doctrines of examination, of report, of recordation, and of preliminary adjudication at each of the most critical stages in the history of a patent. They are applied prior to the grant, at the moment of grant, and prior to and in the course of litigation. These views in respect of principle, and, to a large extent, as to terms, have obtained the sanction and approval of some of the most thoughtful and experienced. It is believed that their adoption would give simplicity and efficiency to the adminstration of the patent law. Their introduction in a practical shape would give to inventors the best security for their interests in their inventions by giving them a limited right of property in those inventions. The creation of such a right of property under the conditions suggested would further be an advantage to the public with the least practical interference with free action, for, being a limited right of property, it possesses the following attributes:—(1) It is capable of precise determination. (2) The duty cast on the public in regard of its use is clearly ascertainable. (3) On the due satisfaction of the actual legal right of the inventor the restraint on the public is removed, whether as regards user or as regards its being made the basis of further improvement. (4) The time of the absolute cessor of the rights of the inventor is fully and openly known to all the world. Founded on these principles, and furnished with these provisions, a patent law, necessarily from the nature of the case a difficult and elaborate branch of the law, would exist, and work in the interests and to the benefit both of inventors and of the public.

NOTES ON A PROCESS FOR THE PRESERVATION OF BUILDING-STONES.

By A. H. Church, M.A.

My attention was directed to the subject of the preservation of stone about 1860. In 1862 I took out a patent for this purpose. The process consisted in the alternate application of solutions of pure baryta and pure (dialysed) silica. The plan was partially successful, and possessed the great advantage of causing no discolouration or efflorescence on the stone. But the solutions were rather weak, and therefore, many repetitions of the process were necessary to secure a effective protection. Then, too, the silica solution failed to penetrate calcareous stone to any appreciable depth, owing to its rapid coagulation. After some years of further experiment, improvements were devised which ultimately resulted in a new and much more successful process. This process, for which a patent was obtained, in 1869, by Ransome's Patent Stone Company, consists in the successive and repeated application of three liquids. The first of these is a solution of monocalcic phosphate, often erroneously termed biphosphate of lime, and first introduced, I believe, for a similar purpose, by Coignet. The second solution is one of barium-hydrate, applied warm if possible; and the third is a dialysed solution of silica, to which small quantities of the ordinary potassium and sodium silicates of commerce have been subsequently added.

It will not be necessary to dwell upon the proper methods of applying these solutions nor upon the details of their manufacture. I may however, mention that there is no difficulty in obtaining the various solutions in a state of sufficient purity and strength, and at a sufficiently low rate, to admit of their economical employment for the purpose in view. And it may be interesting to state that the dialysers employed, which are of the capacity of 6 gallons or more, and of an open bell shape, are found capable of doing their work very successfully when floated on or suspended in barrels of rain-water, or on rafts in a tank or pond; the movement of water below the diaphragm of vegetable parchment increases remarkably the rate of separation.

The reactions which take place between the several solutions themselves and between the solution and the constituents of the objects treated cannot be described in detail. The mono-calcic phosphate becomes chiefly di-calcic phosphate in contact with a limestone, and then, on the application of baryta, a barium di-calcic phosphate is formed. If decay has already taken place, and sulphates have been formed in the stone, these are converted into insoluble and non-efflorescent barium sulphate, while the lime and magnesia thus liberated immediately become phosphated by the subsequent application of the mono-calcic phosphate solution. The siliceous solution finally employed keeps good some time, and penetrates some distance beneath the surface. It contains, indeed, a small quantity of alkalies, but their amount is not sufficient to produce any soluble salts in the treated stone or bricks. It would be tedious to enter into the proofs of this statement furnished by direct experiment. Extensive trials of the new process have been made on many important buildings, some of which have been entirely treated by the three solutions described above. I may cite as examples of the use of the process, the Chapter House at Westminster, and the St. Pancras Midland Terminus; portions of Canterbury Cathedral have also been submitted to treatment, together with numerous other buildings, public and private. Where the direction has been carried out with fidelity the results have invariably promised well. No marked alteration of the appearance of the stone is to be seen after the lapse of a few months from the time of using the process. The waterproofing of the stone effected by the use of the solutions is seen in many ways, particularly when after a shower of rain the colour of the treated surfaces is seen not to be darkened by absorption of water. A piece of black cloth drawn over a piece of Bath or Caen stone after treatment neither blackens the stone nor is itself whitened by it.

I may add, in concluding this very imperfect notice, that my process is one of those just selected (1870) for the renewed trial at the Houses of Parliament. The specimens exhibited are treated and un-treated specimens of the chief stones employed at the Chapter House, Westminster, and at the St. Pancras Terminus.

STEAM BOILER EXPLOSION LEGISLATION.

The constant loss of life from steam boiler explosions has provoked numerous recommendations that the Government should render boiler inspection compulsory, while an act for consigning all the boilers in the kingdom to the inspection of the Board of Trade, has been before Parliament for the last two sessions. In consequence of the great importance of this subject, it was thought desirable that the various plans proposed for legislating with regard to steam boiler explosions with a view to their prevention, should receive the fullest discussion, and therefore the British Association for the Advancement of Science appointed a Committee, consisting of Sir William Fairbairn, Bart., C.E., F.R.S., Sir Joseph Whitworth, Bart., C.E., and others, to report thereon. The Committee was appointed last year at Exeter, and the report was read before the Mechanical Section of the Meeting recently held at Liverpool. As the question is one so intimately affecting all boiler owners, the report may here be given. It is as follows:—

The frequent occurrence of steam boiler explosions, with the loss of life and property caused thereby, was called attention to in a report read before the Mechanical Section of the British Association, last year, at Exeter, and in a paper read the year before that, at Norwich. These sad catastrophes still continue with unabated frequency. In the interval between the Norwich and Exeter Meetings, 46 explosions occurred, killing 78 persons and injuring 114 others. Since then 57 more explosions have occurred, killing 99 more persons and injuring 96 others. So great is the regularity with which these catastrophes occur that it was stated at Exeter that it was to be feared that as many lives would be lost by explosions before the next meeting as had been lost since the last. This, it will be seen from the figures just given, has been more than fulfilled. Taking the average of a number of years, it appears that about 50 explosions occur every year, killing abont 75 persons and injuring as many others.

It is not intended in this report to enter on a consideration of the causes of Steam Boiler Explosions. That has already been done on other occasions. It need, therefore, merely be stated in passing that the experience of another year only confirms the Committee in their opinion previously expressed that explosions are not accidental, and they are not mysterious, but that they arise from the simplest causes, and may be prevented by the exercise of common knowledge and common care. Boilers burst simply from weakness, that weakness arising in some cases from original malconstruction, in others from defective condition consequent on wear and tear, and in others again from neglect of attendants through allowing the plates over the furnace to become overheated from shortness of water, &c., &c. Competent inspection is adequate to detect the weakness of the boiler in time to prevent explosion, whether that weakness arise from malconstruction or from defective condition, while it tends to stimulate attendants to carefulness, and thns to diminish the number of those explosions arising from oversight. It is very generally thought that most explosions result from the neglect of the attendant. Snch however, is not the case. On analysing the causes of the explosions that occurred from the 1st of January, 1861, to the 18th of June, 1870, it appears that 120 explosions, equal to 40 per cent., of the whole number, were due to the malconstruction of the boilers either in the shells or fittings; 88 explosions, equal to 29 per cent., were due to the defective condition of the boilers either in the shells or fittings; 44 explosions, equal to 15 per cent., were dne to the failure of the seams of rivets at the bottom of externally-fired boilers; 38, equal to 13 per cent., were due to overheating of the plates; 5, equal to 2 per cent., were due to excessive pressure of steam throngh the attendants tampering with safety valves; while 1, equal to say ½ per cent., occurred to au economiser, but whether from gas or over-pressure of steam is uncertain; and one other, equal to say ½ per cent., arose from causes entirely independent of the construction or conditiou of the boiler, and may thus be termed "accidental." Of those dne to overheating of the plates, 30 explosions, eqnal to 10 per cent., of the whole number, arose from shortness of water; 6, equal to 2 per cent., from incrustation; 1, equal to ½ per cent., from the nse of boiler compositions; and 1, equal to ½ per cent., from causes requiring further consideration. The total number of these explosions, the causes of which were ascertained, was 297. From this list it will be seen that the two leading causes of the explosions enumerated therein were malconstruction and defective condition, a small proportion only being due to the neglect of the attendants. It may be put shortly, that for every explosion dne to the boiler minder through neglecting the water supply, &c., six are due to the boiler maker or boiler owner, through making or using bad boilers. It is clear, therefore, that the adoption of competent inspection by every boiler owner in the kingdom would do much to prevent tho constant recurrence of boiler explosions, and to save the greater part of the 75 lives annually sacrificed. This fact is now generally admitted, and hence the question is not unfrequently asked,—since competent inspection would prevent explosions, and steam nsers neglect so simple a precaution, why is not inspection enforced by law? Juries in bringing in verdicts consequent on steam boiler explosions, frequently recommend that the Government should render inspection compulsory, and this view appears to be very widely entertained, in consequence of which various plans for legislative enactment have been proposed. The object of this report is to deal with these plans, and give the result of the Committee's deliberations thereon.

This is a particularly opportune moment for the presentation of such a report. Last Session of Parliament a select committee of the House of Commons was appointed to inquire into the cause of steam boiler explosions, and the best means of preventing them, and this committee, whose labours are not yet completed, have been investigating whether it is expedient that boiler inspection should be enforced by law, and, if so, what is the best way of enforcing it. It is therefore important at this time that discussion on this subject should be encouraged, and suggestions from all parties obtained. It is trusted that this report will aid in promoting this object and in arriving at the best means of rendering the inspection of boilers universal throughout the entire country.

With these introductory remarks the committee will proceed to the consideration of such of the plans "proposed for legislating on the subject of steam boiler explosions, with a view to their prevention," as have ome nnder their notice.

Five systems of compulsory inspection appear to be now before the public. These may each be stated, and considered in turn.

Plan No. 1.—It has been proposed that the iuspection of all the boilers in the kingdom should be carried out by the Board of Trade. To this plan there are many objections. On the one hand, it would impose on the government additional burdens, which they have expressed themselves unwilling to incur; while on the other it wonld prove harassing to the steam user. It would, it is feared, be found to work arbitrarily. Such a system would lack that elastioity which is necessary to conform to the convenience of the individual steam user. There would be a great danger of its hampering progress. It would certainly not find favour with the generality of steam nsers, nor ever be voluntarily accepted by them except as the last resort.

Plan No. 2.—A second proposition is that, instead of the inspection being carried ont by the Board of Trade, it should be carried out by town councils or other local authorities, such authorities appointing their own inspectors. This plan wonld admit of more elasticity than the previous one, inasmuch as the inspection would emanate from several centres instead of from one. From the fact, however, of the inspections emanating from several centres instead of from one, an element of discord would be introduced from which many contradictions and many absurdities would ensue. If it were a qnestion of establishing Greenwich time in every market town and country village throughout the kingdom there might be little difficulty in effecting such an object by such an organisation, since Greenwich time by the help of the Astronomer Royal could be put beyond all question, and the work of establishing it throughout the kingdom wonld be one of diffusion and not of origination. To regulate the construction of steam boilers, however, is a totally different matter. The science of boiler making is a growing one. It is in a transition state, and in spite of the amount of information constantly disseminated, great ignorance prevails with regard to it. In consequence of this, one corporation would declare a boiler safe which another corporation would declare unsafe, so that a boiler carried by rail from one part of the country to another might be counted safe at the beginning of its journey and unsafe at the end. For instance: In Lancashire the practice of strengthening flue tubes at the ring seams with flanged joints or hoops of T iron, or other suitable section, is highly approved. In fact it is thought that no high-pressure boiler should be constructed now-a-days without these appliances. In Cornwall, however, nothing can convince steam users of their necessity, and Cornishmen persistently adhere to the ignorant superstition which the Franklin Institute of Pennsylvania endeavoured to dispel thirty-four years ago, viz., that a boiler cannot explode as long as it is properly supplied with water. They appear to believe that furnace tubes, though of great length and diameter, and though worked at high pressures of steam, can only collapse from the neglect of the water supply, or, in other words, from the neglect of the attendant and not of the owner or the maker. In Cornwall, boiler flue after boiler fne collapses, simply from weakness, till the Cornish boiler stands in the return of explosions as one of the most dangerous. These explosions are the result of gross mal-construction, coupled with neglected condition. Yet Cornishmen wou't see it, and they only attribute every explosion to shortness of water. Local administration under such circumstances would be powerless, while, even apart from undue influence, and simply from the want of due experience in so important a matter as the construction of steam boilers, the decisions of local authorities would be frequently contradictory. Such a system would reintroduce the evils we are trying to eradicate from our courts of law, viz., that a verdict given in one court is frequently contradicted in another. Though the plan of entrusting the inspection of all the boilers in the kingdom to local authorities might answer in the neighbourhood of some of the large mannfacturing centres, it would not do so throughout the entire country.

Plan No. 3.—Another proposition is to hand over the duty of inspecting and certifying all the boilers in the kingdom to divers authorised parties, such as accredited boiler makers, private inspection associations, insurance companies, &c., &c. This plan would, like the one just referred to, be liable to produce contradictory verdicts, while it has the additional objection that it fails to secure the responsibility of tho iuspections. To allow certificates to be granted by boiler makers would be a most invidious course. It could not be a wholesome practice, especially under the infinence of keen competition, for one maker to be called in to approve or condemn a boiler, made by another, while the fact that forty per cent. of the explosions that happen are due to malconstrnction, shows that boiler makers are not after all good judges in this matter, a view which is corroborated by the unsatisfactory and contradictory evidence frequently given by them at coroners' inquests consequent on boiler explosions. Further, it is presumed that every boiler owner would have to pay for his own certificate, so that on this system the most indulgent offices would clearly get the greatest amount of custom, and those which only granted faithful certificates would be driven out of the market by the less scrupulous. Under these circumstances it is feared that the sale of certificates would soon degenerate into a sale of indulgences. Besides this, how is this system to be practically worked? Who is to see that the steam user has the certificates on his boilers regularly renewed at they fall out? These certificates would extend for a year only from year each "entire" examination, and would lapse at different parts of the year. A steam user with twelve boilers would want twelve certificates every year, and one of these might fall out each month. Is the Government to undertake the responsibility of seeing that these certificates are regularly renewed? Is it to inspect to inspectors? Such a plan it is thought would be impracticable, while it would be after all but another form of Governmental inspection, and one of a very complicated description.

Plan No. 4.—The fourth plan starts on the same basis as the preceding ones, viz., that of rendering inspection compulsory, and recommends that Parliament should enact that no boiler should be worked unless periodically inspected and certified at least once a year, as safe and trustworthy. Instead, however, of entrusting the duty of carrying out these inspections, and granting the certificates to the Board of Trade, or to the town councils, or other local authorities, or to certified boiler makers, private inspection associations, or insurance companies, it proposes that there should be formed a National Steam Users' Board, and that this board should be empowered to carry out the system of inspection required, including the granting certificates, fixing the rate of charge for each boiler, &c. This board to be an honorary and representative body, about one-half of its members being men of commerce, that is to say, mill owners or others, using boilers for mercantile purposes; and the remainder to be men of science, that is to say, engineers and others, competent to advise on matters relating to the inspection of boilers, and to add weight to the councils of the board. None of the members of the board to retain office longer than four years without re-election, one-fourth retiring every year, so that every four years the board would be entirely recruited, either with new members, or re-elected ones. The board to be appointed in such a way as to secure the fair representation of the general body of steam users, and to merit their confidence, the appointment being effected either by popular election, every steam user having a vote for each of his boilers, or by any other appropriate method. If preferred there might be a number of district steam boards with geographical limits assigned to each, instead of a single national one, and it is well worthy of consideration which would be the better plan of the two. If the plan of district boards were adopted, it would then be well for an annual conference to be held, composed of deputies from each of the district boards, in order that the results of the working of each district might be compared, and this it is thought would promote a wholesome rivalry.

The following are set forth as some of the distinctive features and advantages of this system of administration, and as equally applicable whether the central steam board or the district ones are adopted.

No. 1. This system would throw no administrative responsibility on the Government whether of a financial or engineering character.

No. 2. It would secure the integrity and efficiency of the inspections, inasmuch as the work would not be undertaken for profit, and the board or boards would be established on too wide a basis to be influenced by local or private interests. At the same time the boiler owners would be protected from arbitrary interference, inasmuch as the inspections in each case would be controlled by a board or boards composed principally of steam users, and appointed by themselves.

No. 3. This plan would secure to the country a large amount of valuable engineering information. It would afford the opportunity of ascertaining how many boilers there are in the kingdom, how many varieties of construction, and how many boilers to each class, as well as the various pressures at which they are worked. Also it would afford the opportunity of ascertaining the approximate horse power throughout the whole kingdom, as well as the consumption of fuel for boiler purposes. Added to this it would afford the means, at a perfectly nominal outlay per boiler, of establishing a fund for scientific research on any doubtful questions with regard to the safety and economical working of steam boilers and engines.

The above is but a very brief outline of the fourth plan proposed for carrying out compulsory inspection, and it is found impossible in the compass of this report to enter upon it in detail. The sketch given, however, may be sufficient to afford a general idea. It will be seen that this plan is independent of governmental interference further than the passing of an act, in the first instance, to enforce the inspection of every boiler in the kingdom, and to empower the steam board, or boards, to carry out these inspections and adjust the rates, &c. Thus the steam users would be left to govern themselves, a responsibility with which it is thought they might be entrusted, since they have a strong desire to avoid governmental interference, and they would know that unless they succeeded, the government would take the matter into its own hands. The committee consider this plan calculated to guard the inspections against being lax and contradictory on the one hand, or arbitrary and oppressive on the other, dangers to which the three previous plans would not, they think, afford sufficient protection, and thus they regard the national steam board, or the national system of district boards proposed, as adequate to the prevention of explosions without harassing steam users.

Plan No. 5.—This plan differs from the preceding, inasmuch as it does not propose to enforce inspection directly by law, but to impose a heavy penalty on the occurrence of every explosion, with the view of inducing steam users to take precautionary measures, and have their boilers inspected. With this penalty system it is proposed to ally the principle of steam boiler insurance by joint-stock companies, thinking that while boiler owners would be driven by the penalty to insure, insurance companies would be driven to inspect; as the penalty, though falling in the first instance on the owner, would be ultimately paid by the insurance company.

On considering this proposition it appears by no means clear that a penalty would have the effect of inducing all steam users to enrol their boilers. The incredulity of many as to the possibility of their boilers exploding is so great that nothing would convince them but the occurrence of the calamity itself. It would therefore, it is thought, be some time before the penalty system took effect, and this being the case several lives would be lost in the meantime. Indeed, unless the simple announcement that the government had established a penalty were sufficient to promote general enrolment, the system could not come into force until the penalty were exacted, and before this could be done, explosions must happen, and thus lives be lost. Still the committee cannot doubt, though the effect of the penalty might be tardy in its operation, that in process of time it would induce many steam users, if not all, to avail themselves of inspection.

Passing over the question as to the success of the penalty in promoting inspection, the next question is as to the value of the inspections by competing joint-stock insurance companies. This is by no means a simple subject, and one on which a great deal of misapprehension occurs. A few brief remarks upon it are all that can be offered in the limits of this paper.

Commercial insurance is founded on the principle of a commutation of risks. Given the number of fires that occur per annum on an average, and we have the risk of fire insurance. Given the number of deaths that occur throughout the country per annum, and we have the risk of life insurance. Given the number of persons injured every year by railway travelling, and we have the risk of railway passenger insurance. Now, it will be seen in these cases that the companies adopt little or no preventive measures. It is true that before a house or a life is insured, a general examination is made in each case, but these are not followed up by a series of preventive measures. In the case of accidental death insurance, no precautionary measures are adopted whatever. A passenger, on taking his railway ticket, takes also an insurance ticket, and thereby enters what may be termed a legalised lottery. If he is injured in his journey he receives some return for his outlay; if not, he losses it, and the company gains it. This is a perfectly above-board transaction. It is quite understood that the company adopt no precautionary measures. They do not inspect the railway line, they do not inspect the axles or tyres of the carriages, the points and crossings, the signals or the signalmen. The whole matter is understood on both sides to be simply a commutation of risk, and the company merely profess to insure against accident. Now it will be seen that before this principle can be applied to the prevention of boiler explosions, some serious qualifications must be made. It has already been seen that boiler explosions are not accidental. To term a boiler explosion an accident is to mislead, and thus do much mischief. Boiler explosions may be prevented by common knowledge and common care, and these every boiler owner is bound in justice to his workmen to exercise. A boiler owner has not right to insure himself against the pecuniary results of his own neglect which may cost the lives of his workpeople. To this it may be replied that when the principle of insurance has been applied to boilers, inspection has been coupled with it, and further, that it is the interest of insurance offices that such should be the case, since inasmuch as they have dividends to pay, they are bound to inspect in self-protection. This view obtains very general currency. It is, however, a total fallacy that the joint-stock insurance principle as at present applied affords any inducement to the adoption of inspection. This can be plainly shown in a few words. The object of a joint-stock company is clearly pecuniary profit—not philanthropy, and this being the case, such a company would not expend a pound to save a shilling. Now it appears from data which have been accumulated for years, that the risk of explosion with steam boilers is about one in two thousand, so that the cost of insurance is 1s. per £100. The cost of an annual "entire" examination, which is essential to sound inspection, may be taken in round numbers at about 20s. per boiler. Thus, inspection costs about 20s., while insurance costs 1s., or, at all events, inspection costs much more than insurance. Consequently it will pay an insurance office better to allow boilers to blow up and pay compensation, than to prevent explosions and pay for inspection. Inspection is dear; insurance is cheap. Inspection eats away the dividends. The interest of a joint-stock company, therefore, is to lavish insurance and stint inspection.

There are further points in the mode in which joint-stock insurance is at present applied to steam boilers which may be called attention to. Insurance companies adopt scales of charges according to the risk run, and thus they class the boilers A, B, and C, as they may be first, second, and third rate. This is insuring boilers simply on the principle of risks, and ignores altogether the danger to life. If boilers can only be worked at a risk they should not be worked at all, Again, the charge for insurance rises according to the pressure of the steam. This is to tax progress, and make a market of engineering enterprise. Again, insurance companies charge so much for the first £100 insured on a boiler, the same amount for the second hundred, the same for the third hundred included the charge for inspection. In this arrangement the value of inspection appears to be ignored. The danger of explosion is assumed to be as great after the charge has been paid for inspection as before. An accidental death company, insuring railway passengers' lives, could not adopt a scale of charges that would more consistently ignore the principle of prevention, and adopt that of hazards. Again, insurance companies pay compensation in case of minor damage, which emboldens a boiler owner to neglect any precautionary advice given in consequence of the inspections. If he employ an inferior attendant in order to save 5s. a week in his wages, and the boiler becomes injured thereby, the cost of repair is paid by the company, and not by himself. This system entirely absolves a boiler owner from the results of his own neglect.

These remarks will suffice to show that the principle of insurance as at present applied to steam boilers by joint-stock companies is not all that is to be desired for the prevention of steam boiler explosions, and that before the government will be justified in handing over the inspection of all the boilers in the kingdom to a number of competing joint-stock companies, considerable modifications will have to be enforced, and it will be well now to consider whether the imposition of the proposed penalty would have the desired effect, or whether any other steps would be necessary.

The penalty upon the boiler user in the event of explosion would, as already stated, ultimately fall upon insurance companies, that is to say, in those cases where the boilers were enrolled. Now if that penalty were made sufficiently heavy, it might make it more expensive for companies to permit explosions and pay compensation, than to prevent them and pay for inspection, and thus just reverse the position that obtains at present. For this it would be necessary that the penalty should not be less than £1,000 or £2,000. Added to the penalty imposed on the boiler owner, in the event of explosion, to induce him to enrol, it might be well to impose another penalty of equal amount on the company, more fully to induce them to inspect. The first of these penalties, the one imposed on the boiler owner, should be exacted unconditionally, the other, imposed on the insurance company, only after it had been shown on an examination by a government officer that the company had failed in their duty. Added to the imposition of these penalties, it would be necessary for it to be enacted that no company should have more than one rate of charge, otherwise they would meet the risk on dangerous boilers simply by raising the rate. A fixed rate would also put an end to the taxing of high-pressure steam, as the rate would be the same for 10lb. as for 100lb. Added to this, the present system of insuring against minor damages should be prohibited, as this completely destroys the owner's responsibility. Such are some of the restrictions which it appears necessary to impose upon the principle of joint-stock insurance before it would be applicable by a number of competing companies to steam boilers, with a view to the prevention of explosions.

The Committee are not without apprehensions, however, that though the principle of joint-stock insurance might be surrounded with a series of checks and counter checks, yet that it would lead to inspection being cut down to the lowest possible point. On the other hand, were the inspection enforced by law, and nationally administered either by a central steam board or by a series of district ones, they consider that a far more generous system would be secured. The steam boards, uninfluenced either by private or local interests, or by the desire to accumulate profits, would take altogether higher ground, and inspect, not simply in their own interests, and just sufficiently to narrowly escape explosion, but with a view to assist steam users, disseminate practical information on the making and management of boilers, and promote progress. These objects would be altogether foreign to competing joint-stock insurance companies.

The committee have now stated, they trust impartially, the various plans which have come under their notice, remarking, as they proceeded, on such of the points in each as appeared to them to be defective, and they would now beg to solicit the most ample discussion of this important subject.

In drawing this report to a close, the committee wish to make a brief reference to the one they presented to the mechanical section of the British Association last year, on the subject of "coroners' inquiries in connection with boiler explosions." In that report they pointed out the defects in these investigations, and how necessary it was that improvements should be effected, expressing their belief that full investigation and plain speaking would, of themselves, do much to prevent the recurrence of these catastrophes. The committee still hold this view, and think that had coroners' verdicts been as satisfactory as they might have been, that boiler explosions would not have been as numerous as they now are. With the additional experience of another year they feel compelled to take one other step in advance, and they have come to the conclusion that the time has arrived when the government should enforce the periodical inspection of all steam boilers, though, as already stated, they do not think that the government should turn boiler inspector. They are convinced that explosions might be, and ought to be, prevented; that competent inspection is adequate for this purpose, and that any well organised system of inspection extended throughout the entire country would practically extinguish boiler explosions, and save the greater part of the 75 lives now annually sacrificed thereby.

(Signed on behalf of the Committee.)

William Fairbairn,
Manchester, September 12th, 1870. Chairman.

ROYAL GEOGRAPHICAL SOCIETY.

ADDRESS.

By Sir R. I. Murchison, President.

Alluding first to the explorations of the Central Asian traveller, Mr. G. W. Hayward, he announced that before the treacherous murder of this accomplished geographer by a chief of Yassin, he had prepared and sent home a most highly finished map of Yassin and the neighbouring region, drawn from a general survey which he made on his first excursion into those mountain valleys in February. His last letter would be read that evening. Next in importance to this journey was the expedition of Mr. T. Douglas Forsyth to Kashgar, on a mission to the Ataligh Ghazee of that country. An instructive letter from this able public servant had recently been received, written at Shadulla (at the foot of the Kuen Lun) on his return over the mountains. In it he stated that the mission had at present failed, owing to the absence of the Chief of Kashgar on a military expedition to the north-east. Another letter on the same journey has been received from Dr. Cayley, who accompanied Mr. Forsyth as far as Shadulla, and who himself made a geographical discovery of some interest regarding the routes over the mountains between Shadulla and Changchemmo, on his way back to Ladak. The last reports concerning Dr. Livingstone were next mentioned. These were communicated in a letter from Dr. Kirk, dated the 29th of August last. Many traders had arrived at Zanzibar from the interior, and none of them, in answer to questions, gave any other account than that Livingstone was still somewhere in the interior, either at Karagwe or Ujiji. Abundant supplies had long ago been forwarded to the traveller, and the president dwelt especially on the fact that before the grant of £1,000 made by our Government had reached Zanzibar, all present wants had been met by the liberality of Mr. James Young, an attached friend of Dr. Livingstone, who had placed considerable sums of money at the disposal of Dr. Kirk for that purpose. Among the subjects already in hand for discussion during the earlier meetings of the session were, first, a paper of great importance by Captain Sherard Osborn, on the "Geography of the Bed of the Ocean," which would be illustrated by superb diagrams exhibiting sections of the Atlantic and Indian Oceans and the Mediterranean Sea. Another paper was a narrative of the remarkable journey of Lieut. G. C. Musters, R.N., through the interior of Patagonia; the author of which had spent 14 months among the Indians, and visited the eastern side of the Andes in those latitudes, which no other traveller had before explored. The recent successful pioneer journey overland from Swan River to Adelaide, promoted by Governor Weld, of Western Australia, and carried out by Mr. John Forrest, was next alluded to. Also the discovery, by Mr. Charles B. Brown, of the Geological Survey of British Guiana, of a magnificent waterfall, 730ft. high, on one of the tributaries of the Essequibo, the details of which would form the subject of one of the evening meetings. A series of letters from the late Mr. G. W. Hayward were then read. They were of various dates, from the 17th of February to the 21st of May last, and were addressed to Sir Roderick Murchison and Colonel Showers, of Srinagur. It appears that he started from Cashmere towards the end of last year, and reached the elevated valley of Gilgit, viâ Skardo, on the Upper Indus, where, after some delay, he passed onward between the snowy ranges to Yassin, in the upper part of the same valley, arriving about the end of February. The chief of Yassin, Meer Wulli Khan, received him with marked courtesy and kindness, and promised to assist him with an escort to carry out his design of crossing the Darkot Pass into the region of the Upper Oxus. During his stay here he made many exploring and hunting excursions up the courses of the tributary streams, reaching the foot of the passes which lead on the north into Wakhan, and on the west into Chitral. The passes, however, were still encumbered with snow, and after obtaining all the information then in his power, he returned to Cashmere to remain until midsummer. Meantime he had interested himself in the cause of the mountaineers of Yassin and Gilgit, who, he believed, had been oppressed by the Cashmerian invaders. At the end of June he returned to Yassin, but the last letter received from him was dated the 5th of July from Gilgit. During his stay in the winter and spring he had collected vocabularies of all the hill tribes of the region, and also topographical notes of many valleys which he himself was not able to visit, especially those of Hunza and Nagar and Dilail. Some of the peaks between the valleys reached an altitude of 25,000ft. The passes on the north all led to the Upper Oxus, and not to the tributaries of the Yarkand; he was hence enabled to decide that the mountain range limiting the Yarkand plain was placed much farther to the west than its true position. A carefully drawn map of the whole region, executed by Mr. Hayward, was laid on the table.

INSTITUTION OF NAVAL ARCHITECTS.

SUBJECTS ON WHICH COMMUNICATIONS ARE DESIRED.

The Council of the Institution of Naval Architects have had under consideration the question of providing a good series of contributions for their next session. They have accordingly (with the assistance of a sub-committee specially appointed for the purpose) prepared a list of subjects, which they desire to submit to the members and associates of the Institution as questions on which they will be glad to receive communications for the annual general meeting in March, 1871. They trust that this invitation will be kindly responded to by the members and associates of the Institution and their friends, and that the transactions for 1871 will thus exceed, both in the number and value of the communications, the results of any previous year. To prevent disappointment, it is requested that all such communications may be forwarded to the secretary of the Institution not later than the 1st March, 1871; the council cannot otherwise undertake to find a place for them in their programme of proceedings. It would also be well that gentlemen proposing to read such papers should announce their intention to the secretary as soon after Christmas as may be, in order that he may be able to make suitable preparations for the meeting. In naming these subjects, it is by no means the intention of the council to restrict gentlemen desirous of reading papers on other matters, nor is it intended that the list should be an exhaustive one. It has been thought better to publish a short list at present, so that future lists may present some distinctive features:—

SUBJECTS FOR PAPERS.

1. The armament of ships of war; 2. The construction and armament of ships of war for the protection of commerce; 3. The construction of vessels for coast defence; 4. The effect on naval construction of torpedoes, or other modes of submarine attack; 5. On the results of the best modern practice in ocean steam navigation, with reference to the latest modern improvements—such as surface condensation, superheating, compound engines, and the like; also the value of each of these taken separately, and especially the results of any actual experiments to test this point; 6. On economy of fuel in marine engines, with detailed results; 7. On the life and cost of maintenance of merchant steam-ships; 8. Composite shipbuilding; 9. The design and construction of yachts; 10. On legislative interference with the construction, stowage, and equipment of ships; 11. The effect upon shipbuilding of Lloyd's rules, the Liverpool rules, and the rules of other similar societies for the classification of ships; and on ships not classed; 12. On methods for the proper strengthening of ships of extreme proportions, and on the precautions necessary to ensure their safety at sea; 13. On the present state of knowledge of the strength of materials as applied to shipbuilding, with especial reference to the use of steel; 14. On the masting of ships, and on iron and steel masts and yards; 15. On the disposition and construction of bulkheads, and on their attachment to the sides of iron ships; 16. On the prevention of fouling of the bottoms of iron ships; 17. On machines for the economising of labour in the construction of ships; 18. On the use of machinery for economising labour on board ship, whether merchant ships or ships of war, and whether for loading or manœuvring; 19. On telegraphic or other communication of orders on board ship; 20. On the conveyance of passengers and goods over estuaries and straits, and on railway ferries; 21. On floating structures for special purposes—such as docks, lighters, tank vessels, light ships, telegraph ships, and others; 22. On ships' boats, especially those propelled by steam power, and with particular reference to vessels having little or no rigging; 23. On the steering of ships, and on steering apparatus; 24. On the correction of compasses in iron ships; 25. On the measure and amount of resistance opposed to a ship's progress by the water through which it moves; 26. Exact information (either experimental or theoretical) on the efficiency of propellers; 27. On the economic value of form and proportion both in merchant vessels and in ships of war.

CHARLES W. MERRIFIELD, Hon. Sec.

MANCHESTER STEAM USERS' ASSOCIATION.

CHIEF ENGINEER'S MONTHLY REPORT.

The last ordinary monthly meeting of the Executive Committee of this association was held on Tuesday, October 25th, 1870, Charles F. Beyer, Esq., C.E., of Gorton, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, of which the following is an abstract:—

"During the past month 289 visits of inspection have been made, and 563 boilers examined, 403 externally, 12 internally, 4 in the flues, and 144 entirely, while in addition 5 boilers have been tested by hydraulic pressure. Two of these hydraulic tests were ordinary ones, simply to ascertain the sufficiency of a boiler already in work, while in the other 3 cases the boilers were new ones, and were tested by hydraulic pressure, as well as specially examined, both as regards their construction and complement of fittings, before leaving the maker's yard. In the 389 boilers examined, 71 defects were discovered, 7 of them being dangerous. Furnaces out of shape, 2; fractures, 11; blistered plates, 9,—2 dangerous; internal corrosion, 11,—1 dangerous; external ditto, 12,—3 dangerous; internal grooving, 6; external ditto, 1; blow-out apparatus out of order, 2; safety-valves ditto, 2,—1 dangerous; pressure gauges, 10; boilers without blow-out apparatus, 1; without feed-back pressure valves, 4.

"EXPLOSIONS.

"Just as the Select Committee of the House of Commons appointed to consider the subject of steam boiler explosions were concluding their labours, a lull took place in the recurrence of these catastrophes, and it almost appeared as if the inquiry, by itself, had produced a good effect. Whether that be so or not, this lull has passed over, and explosions are now occurring with their accustomed regularity. Six have taken place during the past month, killing six persons and injuring sixteen others. This brings the list from the commencement of this year up to 40 explosions, 70 deaths, and 92 cases of personal injury.

"The following is a tabular statement of the explosions which have occurred during the past month:—

"TABULAR STATEMENT OF EXPLOSIONS FROM SEPTEMBER 24TH, 1870, TO OCTOBER 21ST, INCLUSIVE.

Progressive No. for 1870.	Date.	General Description of Boiler.	Persons Killed.	Persons Injured.	Total.
35	Sept. 27	Double-flued, or 'Lancashire' Internally-fired	1	0	1
36	Oct. 4	Plain Cylindrical, Camber-ended—Externally-fired	3	5	8
37	Oct. 13	Particulars not yet fully ascertained	0	2	2
38	Oct. 19	Double-flued Horizontal Externally and Internally-fired	1	1	2
39	Oct. 19	Single-flued or 'Cornish' Internally fired	1	2	3
40	Oct. 19	Particulars not yet fully ascertained	0	6	6
		Total	6	16	22

"AN EXPLOSION FROM SHORTNESS OF WATER.

"No 35 Explosion occurred on Tuesday, September 27th, at about twelve o'clock noon, at a paper mill.

"As this explosion took place at a distance of 200 miles from Manchester, and did not appear to be of a very important character, the scene of the catastrophe was not visited by an officer of this Association. I have, however, been favoured with the following brief particulars.

"It appears that the boiler was of the ordinary mill type, and that it measured 31ft. in length, 7ft. 3in. in the diameter of the shell, and 2ft. 10in. in the furnace tubes; the thickness of the plates being three-eighths of an inch in the furnace tubes, and the working pressure from 45lbs. to 60lbs. To this it may be added that there were between fifty and sixty 'Field' tubes applied to each of the internal flues behind the bridge.

"The boiler failed at the crown of the right-hand furnace tube, which bulged downwards immediately over the fire, and rent circumferentially at the ring seam of rivets uniting the second and third plates, when the rush of steam and hot water that followed did considerable damage, scalding a lad to death, as well as scattering the burning cinders. and thereby setting on fire a building in which esparto grass and rags were stored. The whole sprung at once into a blaze, and it is reported that a large amount of property was destroyed.

"The cause would appear from the position of the rupture, and the character of the bulging, to be overheating of the plates from shortness of water, but the fact that the left hand furnace was not injured as well as the right, tends to throw some doubt on this conclusion. Possibly the fire happened to be more active at the time in the right-hand furnace than in the left. or there was some other cause that led to one furnace suffering more severely than the other. Such points as these, in investigating the causes of explosions. frequently require minute examination, and in the absence of particulars in this case, a positive opinion must be reserved, though it is highly probable that the explosion arose from overheating of the plates through shortness of water.

"Though there may be some difficulty in pronouncing a positive opinion on the cause of this explosion, simply from the want of fuller information, there need be no hesitation in again recommending the use of low-water safety-valves. These valves prevent explosions from shortness of water, by relieving the pressure of the steam as soon as the water falls below the desired level, while, should the furnace crowns fail of those boilers fitted with these valves, it must be clear that shortness of water is not the cause, and that further investigation must be made. Thus, these valves are of service, not only in preventing many explosions, but in throwing light on the cause of others. Thousands of these valves are in satisfactory operation, and their general adoption is once more recommended.

"AN EXPLOSION, SHOWING THE DANGER TO WHICH THE PUBLIC ARE EXPOSED FROM OLD WORN-OUT BOILERS HIDDEN AWAY IN THICKLY-POPULATED LOCALITIES.

"No 36 Explosion has excited a good deal of attention in the locality in which it occurred, and most deservedly so, while it is of general interest to all those living near boilers, especially in the heart of crowded cities.

"This explosion occurred at a small foundry at Liverpool, at a quarter before five on the afternoon of Tuesday, October the 4th, killing three persons, one of whom was a lad, and the other two mere children: while in addition, five other persons were injured.

"The interest excited by this explosion arose, not only from three persons being killed, but also from the fact that the devastation was so widely spread, a considerable number of the houses of the adjoining streets being shattered, several passengers on the public thoroughfare fares being struck by the *débris*, and some when in their own homes. On the occurrence of the explosion the foundry at which it happened was laid in ruins, the partition wall between it and the adjoining street was was thrown down, and the *débris* scattered on the pathway. The main portion of the boiler was hurled across an adjoining street, and dashed through the roof of a dwelling house, while another portion was shot into the bedroom of second dwelling-house, severely injuring a woman and two children therein, one of the latter fatally; added to which the side-wall of the upper room of a third dwelling-house was also blown in, and one of the ends of the boiler thrown on to the pavement of the main thoroughfare, at a distance of 25 yards, where it struck down a little girl and injured her so severely that she died shortly after. Also a considerable number of the windows of the houses all round were broken by the concussion consequent on the explosion, so that with the breaches effected in the sides of houses, the entire windows staved in in some cases, and the panes of glass broken in others, coupled with the *débris* scattered over the pathways, the street adjoining the foundry had the appearance of having been bombarded.

"In entering on the cause of this disaster, I do not know that I can do better than give a copy of the joint report presented to the coroner by Mr. Anthony Bower, C.E., and myself. This report is as follows:—

"'To CLARKE ASPINALL, ESQ.,

"'Coroner for the Borough of Liverpool.

"'Sir,—In accordance with your instructions, we have investigated the cause of the explosion that took place with such fatal results on the afternoon of Tuesday, the 4th inst., at the Brunswick Iron and Brass Foundry, Gregson-street, Everton, Liverpool, in the occupation of Messrs. Parry and Duke. In the first place we visited the scene of the catastrophe, witnessing the general destruction, and examining the fragments of the boiler in the positions to which they were thrown by the explosion. Subsequently we made a more detailed examination of the parts of the boiler when removed to the yard belonging to the Municipal Offices, having careful measurements as well as drawings and photographs taken. Having done this, we now beg to present you with our joint report upon this catastrophe.

On examining the fragments of the boiler, we found that it had been a horizontal one, of the plain cylindrical, externally-fired class, having ends slightly cambered. Its size was diminutive, its length over all being 6ft. 4in., and, without the camber at the ends, 5ft. 6in., while the diameter was 3ft. 4in. the original thickness of the plates three-eighths of an inch, and the load on the safety-valve about 80lb.

The boiler gave way primarily at the bottom, rending longitudinally from end to end, at about 3 or 4in. to the left hand of the centre or keel line, when the force of the steam opened out the cylindrical portion of the boiler until it became nearly flat, peeling it away from the ends through the root of the angle irons which had united them. The sudden escape of steam and hot water consequent on this rent, raised the boiler from its seat, and hurled it across the adjoining thoroughfare known as Holford-street, dashing it through the roof, and into the upper bedroom of the dwelling-house No. 13, while at the same time another section of the boiler was shot into the bedroom of No. 23, as well as a large breach effected in the wall of No. 21, added to which, one of the ends of the boiler was thrown across Gregson-street to a distance of 25 yards. Besides this, the foundry was laid in ruins, the 9in. wall separating the works from the outer street blown down, and the *débris* scattered, some of it being shot through the windows of the adjoining houses.

The cause of the explosion does not appear to have been overheating of the plates through shortness of water, to which so many explosions are incorrectly attributed, neither does it appear to have been over-pressure of steam consequent on the sticking of the safety-valve. The explosion occurred at a quarter before five in the afternoon, up to which time the engine had not been at work that day, though it was shortly going to be started for driving the foundry fan, for which purpose the steam was then being got up. One of the partners states that the boiler had been fully charged with water before lighting the fire, and that at the moment of the explosion it was up to within half an inch of the top of the glass, which would have been an ample supply. Added to this, the primary rent being at the very bottom of the boiler, was not where it would in all probability have been, had overheating from shortness of water occurred. With regard to the condition of the safety-valve, the same partner further states that he had tested the valve by hand but a minute or so before the explosion, when he found it free in action, and that the steam escaped from it as he lifted it. He had but just done this and walked a few yards from the boiler when it burst. An examination of the plates of the boiler, left no doubt as to what the cause of the explosion had been. The plates were found to be seriously weakened by external corrosion. Though originally three-eighths of an inch in thickness, they had been so eaten away that they were not more in places at the line of fracture than one sixteenth of an inch thick, or a sixth of what they had been in the first instance. A piece measuring nearly a foot square at the bottom of the boiler had been blown away altogether, the thickness at this part being less than that just mentioned. The effects of the corrosion were apparent at a glance, and could easily have been detected had an examination been made prior to the explosion, the surfaces of the plates giving unmistakable evidence that corrosion was going on, while some of the rivet heads were almost eaten away. The boiler burst, therefore, from weakness, consequent on the ravages of external corrosion, which might have been detected by competent inspection in time to have given warning of the danger, and thus to have prevented the explosion, and saved the lives which have been lost.

While this is briefly an explanation of the cause of the explosion, there are yet one or two points with regard to it which should not be passed unnoticed. It appeared on inquiry that the boiler was an old one, and had passed from hand to hand. It had been at worked for about three and a quarter years at the premises on which it burst, prior to which it had lain out in a yard as a castaway for some considerable time, exposed to the weather, having done service before that. What the origin of the boiler was, we were not able to learn, Possibly some light may be thrown on this point in the course of the inquest. When set to work at the foundry, it was not by any means well equipped. There was no feed pipe, or means of supplying the boiler with water when the steam was up. The course adopted was to let the steam down, take out the safety-valve, fill the boiler up to within an inch of the top of the glass gauge, and then to work the boiler on as long as the water would last. Further, there was no steam pressure gauge, and although it is difficult now to arrive at the precise proportions of the safety-valve lever, it appears highly probable that while the owners supposed they were working at a pressure of 60lb. they were actually working at a pressure of 80lb. A good steam gauge would have prevented this misunderstanding. Added to this, the manhole was not strengthened as it should have been with any mouthpiece, the cover being an ordinary internal one, held up by a couple of suspension bolts and dogs, the tendency of which is to draw the cover through the manhole, and split it open. Many explosions have occurred from this cause, and every well-appointed boiler is now guarded at the manhole with a suitable mouthpiece. In this case, the manhole showed signs of considerable straining, and seemed rapidly approaching the bursting point. One other circumstance may be mentioned. About six months before the explosion, one of the partners, in company with a fitter in their employ, made an examination of the boiler, both of them getting inside it. When their examination was completed, the fitter assured the owner that the boiler would last him his lifetime. This incident is of interest as showing how deceptive home-spun boiler inspection frequently is, and the necessity for a competent and independent system. The owners state that they were altogether ignorant that there was the slightest danger, which appears to have been the case from the fact that they were constantly risking their lives by working near the boiler, and were within a few yards of it at the moment of explosion.

"'Here then was an old, worn-out, badly equipped, and thoroughly dangerous boiler, working in the heart of a populous district, and only cut off from a public thoroughfare by a wall 9in. thick, which afforded concealment but no protection. The danger was entirely unsuspected until the shock of the explosion was felt, and three persons were killed, and five others injured. We have reason to know that this boiler is not singular, and that many others are to be found working under similar circumstances, dangerously jeopardising the lives of those around them. Boilers are now to be found everywhere. They are sometimes set under the pavements on which the public tread. They are sometimes, as in this case, behind walls, close to which the public walk. They are sometimes in the basement of buildings crowded with busy workpeople. It has been the duty of one of us to examine several such boilers after explosion, and we are sure that many lives are now in jeopardy. Yet all this danger might be averted by the adoption of the simple precaution of competent periodical inspection. We must leave it to the jury in their wisdom to decide whether they think it right, under these circumstances, to append to their verdict any recommendation for the legal enforcement of an organised system of periodical inspection, with the view of saving human life, but we felt it our duty to lay these facts before them, as we cannot consider this explosion as otherwise than a representative one, and that many others of a like character must quickly follow unless some general system of inspection be shortly adopted.

"'Recommending this matter to the best consideration of yourself and the jury, "'We remain, Sir, &c.,

"'(Signed) ANTHONY BOWER,

"'Of the Firm of Messrs. Forrester & Co., Vauxhall Foundry, Liverpool.

"'(Signed) LAVINGTON E. FLETCHER.

"'Chief Engineer to the Manchester Steam Users' Association.

"'October 12th, 1870.'

"At the inquest, the evidence given more than corroborated the statements in the report with regard to the history of the boiler. It appeared that it was bought as a second-hand one from a boiler jockey in the year 1859, being supposed at that time to be about eight years old. It was then worked for some four years, then allowed to lie at rest for about two, and then laid out in the yard exposed to the weather for some two years more. After that, it was sold at an auction, when it was purchased for the foundry use, where, after about three and a quarter years, it burst as already described. The jury brought in a verdict of 'Manslaughter' against the owners of the boiler, and urged the importance of the general adoption of competent inspection.

"The lesson from this explosion is plain. Boilers are now to be found in the most crowded parts of our large towns, whereby, as this and other similar explosions prove, the lives of men, women, and children living nearm them, or even casually passing by, are endangered. These boilers are set up in their midst without their knowledge or consent, while they have no control whatever in their management. Under these circumstances the public have a claim upon the Government for protection, and it would appear that there is no other plan of affording that protection than that of enforcing by law, the universal adoption of competent periodical inspection."

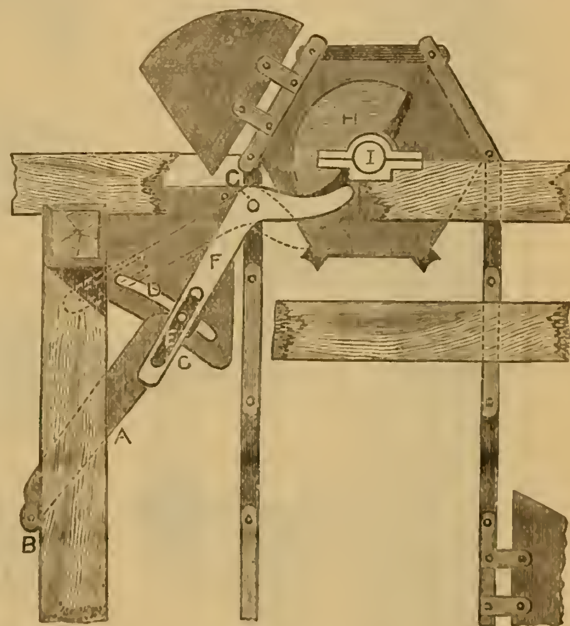
IMPROVED ELEVATOR.

By T. F. RUDIGER, (U.S.)

This elevator has for its object the prevention of the waste of power, involved in the usual description of elevator through imperfect delivery of the material, by which a considerable amount usually falls down between the bucket and the shoot only to be raised a second time. In order to accomplish this object, the shoot is made moveable, being placed directly under the bucket when in the act of delivering its contents, while it is afterwards moved out of the way to admit of the descent of the bucket.

The following description of the accompanying engraving will explain its action :—

The spout or shoot A, is jointed at the lower end, B, and the upper end is mounted on the bar or rod, C, the ends of which are arranged in curved guides, D. This rod passes through the slot, E, of a lever, F, pivoted at G, and projecting at the upper end into the path of a cam, H, keyed on the shaft, I, of the upper elevator drum. The gravity of the spout, A, rod C, and the lever F, causes the spout to fall back at the upper end, under the buckets, so as to receive all the contents thereof, and the cam H, is so arranged that just previous to the arrival of the bucket in the downward movement to the upper end of the spout, it will



strike the upper end of the lever F, and throw the spout up out of the way of the bucket. In this case, the buckets are so placed on the chain that one will pass over with each revolution of the cam ; but it is evident that if more are applied, more cams may also be used to throw up the spout as often as a bucket passes.

SELF-CLEANSING WATER TUBE BOILER.

Our readers will remember that in Plate 357 in THE ARTIZAN of February last, we gave a compendious illustration of the different varieties of boilers suitable for yachts, and also for land purposes where economy of space or weight was desirable. Amongst other descriptions were illustrated several water tube boilers, including the pendulous water tube boiler on the principle patented by Mr. Field. We then expressed a doubt whether this class of boiler was suited to dirty water, and it now appears that the inventor of the boiler illustrated below, was also aware of that failing and has endeavoured to overcome it. We will, therefore, as a supplement to plate 357, lay before our readers the following illustrated description of a boiler recently patented by Mr. Pinchbeck, of Leadenhall-street, London, which, we understand is giving great satisfaction, as it overcomes the great objection to the use of water tubes :—

"The superiority of vertical water tube boilers as rapid steam generators over every other class, has been gradually forcing itself upon the attention of engineers and employers of steam power. The main objection to their universal employment is to be found in the fact that usually waters are so impure that the tubes in a very short time become filled with deposit, necessitating the withdrawal of the internal tube, and the insertion of a small hooked rod to draw out the accumnlated deposit. This tedious process has from time to time to be repeated in proportion to the

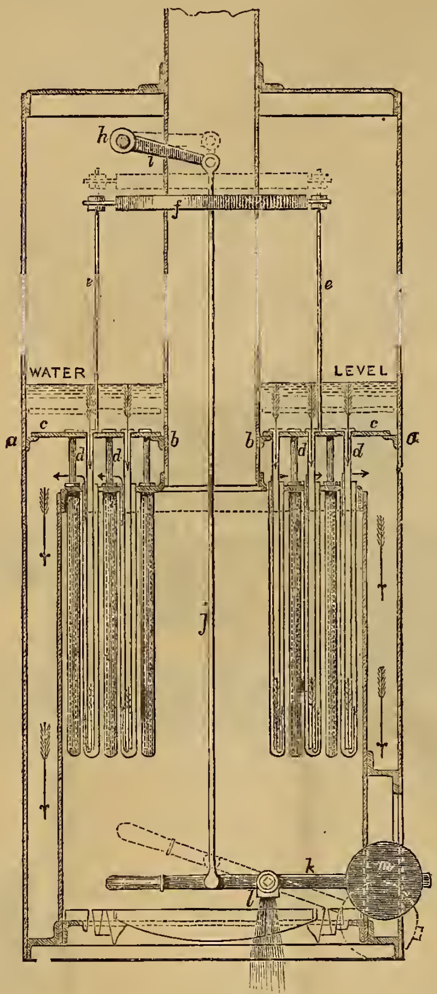


Fig. 1.

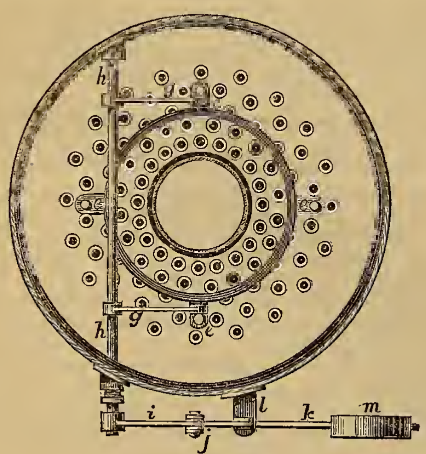


Fig. 2.

degree of impurity; with salt water the case was still worse. The object of the patentee of this boiler is to overcome this difficulty, and by the simple opening of a blow-off cock to cause a strong simultaneous flushing of the whole of the tubes. This, as will be seen from the accompanying illustration, is accomplished in a very simple and effectual manner.

"Fig. 1 is an illustrative vertical section, and Fig. 2 a cross section of a vertical water tube boiler. The angle iron rings *a* and *b* are fitted to the interior of the boiler. The movable plate *c* carries the inner or circnlating tubes, which, when blowing through, is held, and forms a joint on, the angle iron rings. This plate is connected by four rods *e e e e* to a ring *f*, this ring is jointed by the levers *g g* to the rocking shaft *h*, one end of which passes throngh a stnffing-box outside the boiler, and on the end is keyed the lever *i*, which is connected to the blow-off cock handle *k*—the weight *m* being sufficient to cause the blow-off cock to close, unless held open by hand. The dotted lines show the position of the blow-off lever, ring, and plate when not blowing through; when therefore, the cock-handle is brought in the position shown in full lines, the ring is depressed, and with it the plate which now rests upon the angle iron, thereby cutting off the communication above the plate *c* with the rest of the boiler, therefore, the steam and water of necessity take the direction shown by the arrows, and a perfect cleansing of each tube is obtained."

SHIPBUILDING ON THE CLYDE.

The shipbuilding trade on the Clyde continues moderately brisk, though the orders received during the past month have not been equal to those during the two preceding months; nor have the number and tonnage of vessels lannched been equal to the figures of the corresponding months of the three preceding years. The proportion of sailing vessels launched during the month was smaller than even the insignificant ratio of Angust and September. The following are the numbers and tonnage of vessels launched during the month and ten months as compared with the corresponding periods of previous years:—

	Month.		Ten Months.	
	Vessels.	Tons.	Vessels.	Tons.
1870	8	7,200	156	144,200
1869	22	10,000	180	160,100
1868	24	27,000	179	146,000
1867	13	11,000	157	99,000

The vessels launched were:—

City of Oxford, 2000 tons, 200 horse power, by Messrs. Barclay, Curle and Co., for Messrs. G. Smith and Sons, Glasgow, for the Clyde and East India trade, *viâ* the Suez Canal.

Tiber, 1,500 tons, 150 horse power, by the London and Glasgow Engineering and Iron Shipbuilding Company, for Messrs. J. A. Dunkerley and Co., Hull, for the East India trade, *viâ* the Snez Canal.

Marina, 1,350 tons, and 135 horse power, built by Messrs. Barclay, Curle and Co., for Messrs. Donaldson Brothers, Glasgow, for the Clyde and South American trade.

Shiraz, 1,130 tons, 100 horse power, by Messrs. A. Stephen and Sons, for Messrs. Gray, Daws and Co., London, for the Thames and East India trade, *viâ* the Snez Canal.

Alert, 730 tons, and 90 horse power, by A. Stephen and Sons, for the coasting trade.

King Ja Ja, 206 tons, by Messrs. J. and R. Swan, for Messrs. Miller and Co., Glasgow, for the West Coast of Africa trade.

Cogan, 100 tons, and 50 horse power, by Messrs. Hamilton and Co., for the Bombay river and coasting trade.

Agnes Brown, schooner, 182 tons, by the Irvine Shipbuilding Company, for an Irvine firm, for the West India trade.

Messrs. Dobbie and Co., of Govan, launched on the 22nd ult., a screw steamer of 200 tons burden for Messrs. John M'Farlane and Co., Glasgow, named the *Viking* by Mrs. Turner, of Tarbet, Loch Lomond. She is to be engined by Messrs. W. King and Co., engineers, Glasgow.

Messrs. Alexander Stephen and Sons launched on the 22nd ult., from their shipbuilding works at Kelvinhaugh, the fine new composite sailing ship *Lima*, of 885 tons, and built to the highest class in Bureau Veritas. The *Lima* is to be employed in the American and Eastern trade. Being the last ship Messrs. Stephen will build at their Kelvinhaugh works, the ceremony of naming was performed by Mrs. Alexander Stephen.

A fine new iron screw-steamer, built and engined by W. Simons and Co., was launched on the 22nd ult., from the London Works, Renfrew. This vessel is the property of Messrs. Hunter and Grange, and is intended for the China trade. It was named *Migota* by Miss Grange, of Ayr. Messrs. Simons have also in progress three powerful dredgers for Stockton, Dundee, and the Clyde; also, three large screw-steamers, with compound engines. They are also constructing componnd engines, of 150 horse-power, for an eminent shipbuilder in England.

MURRILL'S AUTOMATIC DAMPER REGULATOR.

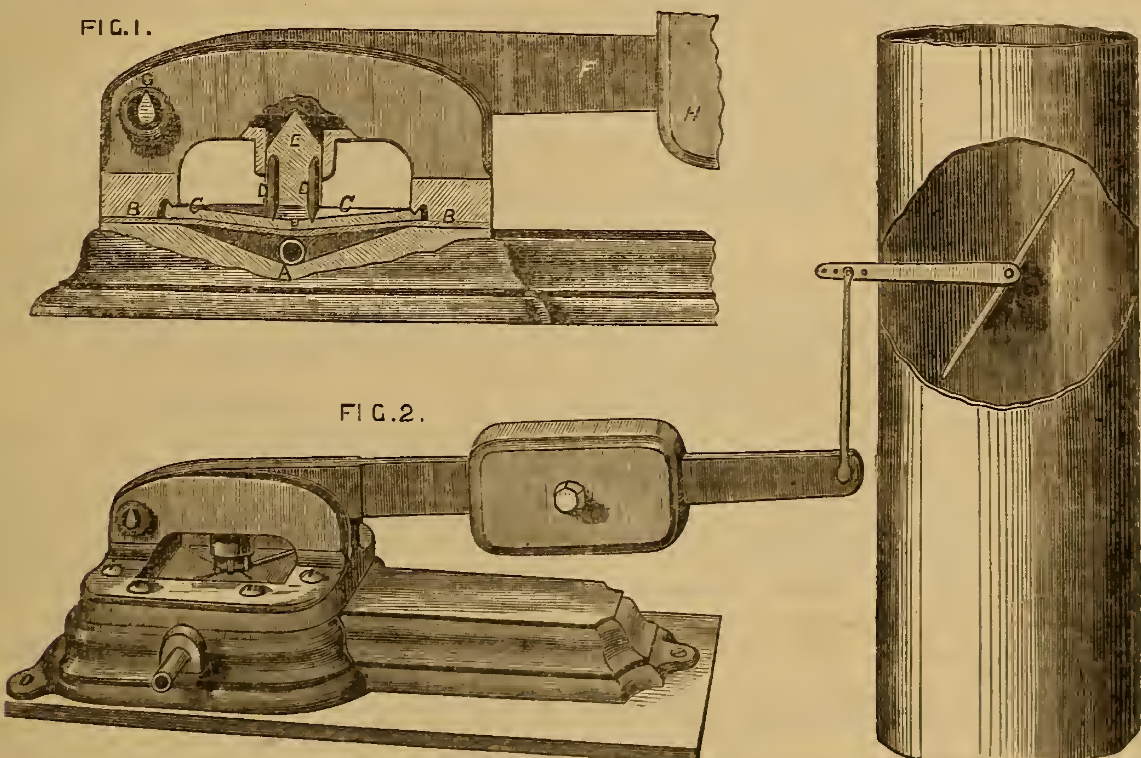
A simple and reliable damper regulator for steam boilers, sensitive to slight variations of pressure, and durable in all its parts, has long been sought. Various devices have been introduced at different periods since the invention of the steam engine for the purpose of controlling and regulating the draught of the fires, which have failed to effect the desired purpose on account of friction, rigidity of parts, etc. The rubber diaphragm answered the purpose in all respects, except that the protection of the rubber diaphragm, in its changes of form and motion, offered difficulties which it is claimed the invention herewith illustrated has fully obviated.

We are assured that it has been fully tested, and that its operation is satisfactory.

It is simple in construction, apparently not liable to derangement, practically frictionless in all its parts, and entirely protected from the obstructive effects of dust and dirt. The operation of the machine is as simple as its construction.

FIG. 1.

FIG. 2.



The rubber diaphragm, B, Fig. 1, being protected by triangular flat metal plates, C, hung on knife-edges communicating motion to the lever as shown in Fig. 1 at D and E, makes the machine sensitive to the slightest variation of pressure, and at the same time the diaphragm is relieved from any undue strain whatever through its extremes of motion. The lever, F, with its counter poise, H, has a knife-edged bearing, shown at G. Steam is admitted under the diaphragm at A.

When the machine is attached to the boiler, and connections made with the damper-rod, the weight on the lever is placed at the point that will balance the required pressure, the position of the damper in the chimney being partially closed.

Any additional pressure will of course close the damper entirely, thereby shutting off the draught and preventing the heat from escaping out of the chimney, until the steam pressure decreasing the weight gradually descends, and opens the damper, admitting sufficient draught to the fire to keep the steam at the required pressure.

REVIEWS AND NOTICES OF NEW BOOKS.

The Loss of H.M.S. Captain. By ADMIRAL FISHBOURNE. E. and F. N. Spon, Charing Cross.

At first sight this might appear to be only one more production to be added to the already extensive list of published opinions of nautical men upon naval architecture; we feel sure, however, that many of our readers, and especially those most interested in this subject—naval architects—are too well acqnainted with the well known treatise on Naval Architecture, which was written by Admiral (then Captain) Fishbourne abont 20 years ago, and which has ever since been considered a first class authority.

Admiral Fishbourne at the outset, emphatically denies, that the low freeboard of the *Captain* occasioned any diminution in her stability, and, moreover asserts, that it was not the pressure on the sails that was the cause of the calamity. Thus, he says, "I assert that the loss of the *Captain* was due to the fact, that there were elements in her original design, which she had in common with several other ironclads, which could not but produce a vessel with very insufficient stability, both for general utility and for safety, and this irrespective of her low side." The Admiral then proceeds to illustrate by means of diagrams, the true cause of the upsetting of the *Captain*, and comes to the conclusion that the centre of buoyancy was too far below the centre of gravity, which he shows was principally owing to the celular bottom. This celular bottom which our readers are aware is common to most of our later ironclads, the author emphatically condemns in the following words:

"If any person would desire a more palpable proof of their tendency, he has but the next time he sees anyone learning to swim with corks, first to place them in the proper position under his arms, and then to attach them to his feet; I will warrant they will drown him, as the cells did the *Captain*, unless provision is made to prevent it, as should have been done for the *Captain*, by placing ballast in these cells, or better, have modified her in design. It will be said we cannot reduce the displacement by the amount of these cells, and double bottoms are so safe. Wonderful! The bottom is protruded 2ft. or more down in search of rocks, that the ship may be safe from foundering if she finds them. My theory is that a ship would be much safer from rocks, and certainly more useful, if she drew less water by 2ft. But surely it is not reasonable to make provision to escape a problematical danger by an arrangement that injures materially and permanently all the good qualities of a ship, viz., her power of carrying sail, of fighting her guns, of steering, and which at the same time makes it quite certain that she must capsize if subject to certain circumstances."

The result at which the Admiral arrives, is that at the time of the catastrophe, the *Captain* must have been lying nearly parallel to the waves and being heeled over by one extending nearly her whole length, so far altered the relative positions of the centres of buoyancy and gravity that she must of necessity turn bottom upwards. This is very clearly illustrated in Admiral Fishbourne's pamphlet, and we heartily recommend it to the attention of naval architects, and all others interested in this most important question.

NOTES AND NOVELTIES.

MISCELLANEOUS.

The Union Rolling Mill Company of Chicago, is about to erect a building and commence preparations for the manufacture of Bessemer steel. Additional land has been purchased in Bridgeport, and a building 150ft. by 250ft. is to be erected, which will afford room for apparatus sufficient to manufacture 100 tons of Bessemer ingots daily. It is intended to commence next spring with a daily product of 50 tons, and increase according to the demand and facilities.

Mr. J. Black, of Bennet-street, Greenwich has contrived a sea messenger of a spherical shape, to be kept ready for an emergency on a stem fixed on some part of the ship's deck. It has a tube in it for passing over the stem, which tube is water-tight at the seams. The tube carries a rubber ring or a metal spring, which is caught hold of by a hook on the inner face of the cover, when the cover is in place over the opening or mouth of the spherical vessel. The top of the stem is threaded for the reception of a nut formed with blades like a screw propeller. The nut is screwed down upon the sphere with a slight grip, so that, should the vessel go down, the rush of water against the blades will unscrew it, and allow the sphere to rise up the stem and free itself. The capacity of the sphere is sufficient to hold the ship's papers and jewels, or other property or great value and small compass, on board, and these would be kept quite dry by the close fit the cover obtains through an india-rubber flange pressing upon the mouth, against which it is kept by the power of the spring or ring before referred to. It requires no preparation or care on the part of any person on board. All that has to be done is to place the papers, &c., inside, and then close up the opening, when it is free to release itself as before named.

Preparations for the Smithfield Club Cattle Show were commenced actively at the Agricultural Hall on the 23rd ult. The entries are exceedingly numerous, and some of the space under the galleries usually occupied by machinery and implements will have to be appropriated to live stock There will be nearly 400 head of cattle, and about 600 head of sheep. In the show of pigs, however, there will be a falling off, as not more than 100 will be exhibited. The amount of money prizes awarded by the club will be £1,385 for the thirty-six classes of cattle, £650 for the twenty-five classes of sheep, and for the nine classes of pigs £135, irrespective of the various plates and cups. The annual dinner of the club will this year be dispensed with, and the prizes will be publicly presented some time during the show.

RAILWAYS.

Darjeeling.—The government of India has at length again taken in hand the consideration of the railway from Calcutta to the hills, and has directed Major Taylor to begin a survey.

A railroad with rails of wood has recently been built from Quebec through the village of Jacques Cartier, about fifteen miles. The Quebec *Chronicle* speaks of it as follows: "The problem of wooden railways for colonization purposes may now be said to be solved, and as a proof of it, it is necessary to say that we passed over the road yesterday at a rate of from twenty to thirty miles an hour, a speed which is seldom surpassed on any of the iron roads in this Province. The cars conveying the party yesterday were simply rudimentary vehicles, known as platform carriages, but sufficient evidence was given that the line when completed will be as easy and smooth for travelling purposes as upon the old established iron or steel rails. The road is built upon a 4ft. 8½in. gauge, being the ordinary width of the modern English and American railways. Each rail is 14ft. long, 7in. in depth, and 14in. in width—sawn and prepared at a temporary mill recently erected by the contractor on the line for the purpose. Each rail rests on several sleepers to which they are fastened by wedges—by a process so simple that the rail when required, can be removed or reversed by any ordinary mechanic. The locomotive is from the Rhode Island Iron Works, and is most assuredly a splendid piece of mechanical ingenuity, while it is supposed to weigh 21 tons, loaded, without the tender."

The Birkenhead Joint Railway is to be diverted by means of a tunnel from Monks' Ferry to the vicinity of Woodside Ferry.

Tenders have been received by the Victorian Board of Lands and Works for the construction of new goods sheds, platforms, &c., for the Melbourne terminus of the Victorian railway lines. The lowest tender was that of Mr. J. Thomas; Mr. Thomas, offers to execute the works required for £45,000.

St. Petersburg telegrams state that the subscription for the new railway loan of £1,500,000 resulted most successfully, the applications amounting to five times the sum to be allotted—a circumstances that seems to indicate an absence in that city of any apprehensions of political difficulties.

The Russians announce the completion, in a few months, of the important railway between Poti and Kutais. When continued to Tiflis it will, it is expected, attract the greater part of the Persian trade.

The Emperor of Austria has sanctioned two new railway concessions—viz., a line from Lundenburg via Feldsherg and Nikolsburg to Grusshach, which will connect the Northern Railway Company's lines with the link line system of the State railways; and, next, a line between Brünn, via Pilsen, to Iglau. Neither of these concessions require confirmation by the Reichsrath, the Government not having given any guarantee or special rights besides temporary exemption from taxes.

TRAMWAYS.

A prospectus has been issued of the North Metropolitan Tramways Company, with a capital of £330,000, in shares of £10, of which £232,500 is offered for subscription. An amount of £46,500 capital was issued for the double line of tramway from Whitechapel to Bow Church, which was opened on the 9th of May last, and is stated to have been since worked at a profit at the rate of 12 per cent. per annum, and it is now proposed to extend the communication from Bow Church to Leytonstone, and also to lay down a tramway from the Archway Tavern, Highgate, *viâ* the Holloway-road, the Liverpool-road, and the City-road, to the Bank. Messrs. Fisher and Parish are to construct the new lines, and to equip them with carriages, horses, harness, stabling, officers, &c., for £225,000.

Parliamentary powers are being sought to construct a line of tramway through some of the principal streets of Newcastle. The line will extend from the Scotswood Suspension Bridge suburb on the west to Shieldfield on the east. Throughout the whole line the gradients will be comparatively easy.

MINES, METALLURGY, ETC.

In Scotland, an iron district, said to be of extraordinary richness, is about to be opened in the vicinity of the Pentland Hills, a few miles from Edinburgh. The Glasgow Iron Company and the Shotts Iron Company have already concluded leases with the proprietors. The new fields include 20 workable seams of coal, of an aggregate thickness of 100ft., two seams of cannel coal of 24in. and 18in. thick, a 15in. seam of very valuable oil shale, and two seams of black-band ironstone, 2ft. 9in. and 18in. thick respectively. The ironstone yields a ton of pig from 32 cwt. of ore.

The coal veins of the mines on Bear River, Utah, near Evanston on the line of the Union Pacific Railroad and about 60 miles north-east of Salt Lake City, are 42ft. thick. Of the quality of the coal the Omaha *Herald* says: In heating power, it ranks next to anthracite, and being utterly free from even a trace of sulphur, yielding 72 per cent. carbon, and only 2¾ per cent. ash, without the least clinker, we leave the reader to judge of its excellence.

Mr. T. W. H. Hughes, of the Geological Survey Department, has been deputed to the Central Provinces of India, to report upon the economic resources of the coalfields of the Wurda river, and also to indicate the line of railway which would best accommodate the coal workings. Limestone, copper, and iron have been found along the Bhutan frontier, and in Darjeeling.

The *Iron and Coal Trade Review* announces that an immense deposit of iron ore, lying in one of the newer geological formations, has recently been discovered in the south-west of England. It is reported to occur in a seam of considerable thickness, and to contain on the average 30 per cent. of metallic iron.

TELEGRAPHIC ENGINEERING.

When the Russian American telegraph is completed the following feat is possible: A telegram from Alaska for New York, leaving Sitka, say at 6.40 on Monday morning, would be received at Nicoleaf, Siberia, at six minutes past one Tuesday morning; at St. Petersburg, Russia, at three minutes past six Monday evening; at London twenty-two minutes past four Monday afternoon; and at New York at forty-six minutes past eleven Monday forenoon. Thus, allowing twenty minutes for each re-transmission, a message may start on the morning of one day, to be received and transmitted the next day, again received and sent on the afternoon of the day it starts, and finally reaches its destination on the forenoon of the first day, the whole taking place in one hour's time.

The telegraph clerks in Canada have found out how fast an earthquake travels, and they put the pace at about 200 miles a minute. At Mimouski when the late earthquate came upon them, they sent at once to Quebec, a distance of 200 miles, to ask "How do you feel?" While the operator there was at his work the shock arrived. He at once sent to Montreal, about 200 miles further on, to ask if they had felt it. They had just time to say "No" before the earthquake came up. We suppose this is the first instance on record of men talking across the edge of an advancing earthquake.

Captain Papafy, a Hungarian officer in the United States service, is the inventor of a new nocturnal military telegraph, which he has just sold to the Prussian War Department. By means of this telegraph, which consists of rockets of different colours, a communication can be established between two armies stationed at a distance of twenty miles from each other. Each rocket represents six words, and an order containing 300 words can thus be conveyed by 50 rockets. The key to this telegraph, which may be altered so as to make it unintelligible to the enemy, contains all the words used in strategy and tactics. The price of one of these rockets is said to be about two shillings.

Materials have arrived from New York for the construction of 120 miles of telegraph about to be erected in Salvador South America. The points proposed to be connected are Santa Ana, Ahuachapon, Sonsonate, and the port of Acajutla.

Telegraphic communication between England and the Channel Islands was effected on the 10th ult.

SHIPBUILDING.

A greater tonnage of iron ships is now in course of construction on the Humber than at any previous time in the history of iron shipbuilding. Messrs. C. and W. Earle have on the stocks in their yard seven large steamers—one of 2,000 tons, for a London house, four of 1,800 tons, each for Messrs. Wilson, Sons, and Co., Hull, the owners of the Wilson line; and two of 2,000 tons each, for Messrs. Norwood and Co. Messrs. Humphrys and Pearson have four large vessels in course of construction, and at both yards orders are in hand for other ships, which will be laid down as the stocks are cleared of those now building. On the 26th October Messrs. Earle launched from their yard the largest steamer ever built at Hull. This vessel which has been built for Messrs J. Moss and Co., of Liverpool, was christened the *Canopus* by Mrs. Oswald Earle, of Liverpool, on behalf of Mrs. J.R. Moss, of Alexandria. The *Canopus* is intended for the trade between Liverpool and Alexandria. She is 400ft. long, 37ft. beam, and 27ft. 9in. deep. Her gross tonnage is about 3,000, and her actual horse-power from 1,500 to 1,600.

We understand that Messrs. R. Napier and Son and Messrs. Elder and Co., have each been entrusted by the Admiralty with the construction of an armour-clad turret vessel of about 2,000 tons.

STEAM SHIPPING.

The *Iron Duke*, 14, double-screw, armour-plated iron ship, is about to have the water ballast in her double bottom replaced by 360 tons of what is termed concrete ballast, consisting of two-thirds of Portland cement and one-third of scrap iron. This will be placed over the whole bottom (in the lower sectional spaces of the double bottom), and, besides greatly increasing the stability, will very considerably strengthen the ship. It has also this advantage, that it does not fill the entire space, so that, if exceptional circumstances should arise to render it necessary, water could still be admitted into the double bottom over the concrete. This sort of ballast is also to be supplied to other ships of the same class.

At Keyham Dockyard, on the 4th ult., Mr. Barnes, Assistant Constructor of the Navy, from the Controller's Office, Whitehall, was on board the *Invincible*, to test her power of inclination. Sixty tons of iron ballast were used, all being put first on one side and then on the other. The ship heeled about six degrees each way. This was with 300 tons of water ballast in the double bottom, the boilers being empty at the time. There was no powder or shell on board, but six months' stores and provisions. The day was beautifully calm, and the ship had her topgallant-yards across.

Messrs. Rathbone, Brothers, and Co.'s screw steamer *Arcturus*, Captain William Lee, which arrived on the 31st October, has completed the round voyage from Liverpool to Calcutta and back to London in three months and ten days, including all stoppages at Calcutta and on the way. Her outward passage of 35 days from Liverpool to Calcutta, including stoppages in the Canal and elsewhere, is by several days the shortest yet made.

A company has been formed under the title of the Cape and Natal Steam Navigation Company Limited, for the purpose of establishing a line of powerful steamers from London to the Cape, Algoa Bay, and Port Natal. The steamers are intended to sail once a month or oftener if required, from London, and will call at a port in the Channel to embark passengers, calling also at Madeira and St. Helena outwards, and homewards at Cape Town, St. Helena, and Madeira, performing the voyage, it is expected, each way in thirty-five days' steaming.

APPLIED CHEMISTRY.

Tungstate of Soda to form an Elastic Mass.—Dr. Sonnenschein, says when glue, in thick solution, is mixed with tungstate of soda, and hydrochloric acid is added, there is thrown down a compound of tungstic acid and glue, which, at from 30° to 40°, is so elastic as to admit of being drawn out into very thin sheets. On cooling, this mass becomes solid and brittle; but, on being heated, it becomes again soft and plastic. This material has been successfully employed, instead of albumen, in calico-printing, in order to fix the aniline colours upon cotton.

MAGNESIUM AS A REDUCING AGENT.—Metallic magnesium in the form of powder is a powerful reducing agent. A solution of chloride of platinum is instantly decomposed by it at ordinary temperature, and with strong evolution of hydrogen gas, the finest platinum sponge separates. Pure gold in powder can also be precipitated from the ter-chloride, and even chloride of zinc is decomposed and the metal separated by magnesium.

MR. GAFFIELD, of Boston, has shown that while chemical rays to a slight degree will pass through yellow glass, they are perfectly excluded by green and red. Thus it was suggested to photographers to substitute green glass for the yellow in the developing and fixing room. The yellow light is very trying to the eyes, while the green light is very agreeable. Mr. Carey Lea recommends the green glass, after an experience in the preparation of hundreds of plates where it had been substituted for the yellow panes.

PROFESSOR SEELY states that he has made the discovery that ammonia has a solvent power upon certain metals, and that he has actually succeeded in obtaining a solution of sodium in liquid ammonia. This solution presents all the physical characteristics of a true solution. On evaporation, the sodium is gradually restored to the metallic state in the same continuous manner in which the solution has been effected. The colour of the solution is a very intense blue, and its opacity or high tinctorial power is urged as an argument in favour of the notion that the metal is in simple solution. Weyl had made the discovery that when gaseous ammonia is condensed by pressure and cold on sodium, a blue liquid is the product, but he had mistaken the nature of this product. Professor Seely has experimented on various substances, and has concluded that metals can be dissolved in ammonia.

LAUNCHES.

MR. J. G. LAWRIE launched, at Whiteinch on the 9th ult., a steamer of 1,800 tons, built to the order of Messrs. Hargrove, Ferguson, and Jackson, of Liverpool. The vessel on leaving the ways was named the *Orchis* by Miss Hargrove.

THERE was launched on the 25th October by Messrs. Barclay, Curle and Co., Stobcross, another steamer for Messrs. Donaldson Brothers' recently opened steam service from the Clyde to South America. This vessel, the *Marina*, is a spar-decked screw of 1,350 tons register, and is, in arrangements and finish, similar to the *Astarte*, launched a month or two before for the same line by these builders. The *Marina* is being fitted by them with engines on the compound high and low pressure principle.

A HANDSOME iron barque, of 400 tons register, was launched on the 9th ult. by Messrs A. M'Millan and Son, Dumbarton, for Messrs. Robert Douglas and Son, of that City intended for the China and Colonial trade. She was gracefully named *Ardentinny* by Miss Douglas, daughter of the senior partner.

MESSRS. ALEXANDER STEPHEN AND SONS launched from their works at Kelvinhaugh, on the 27th October, the fine new iron screw-steamer *Alert*, 730 tons and AE at Lloyd's. The vessel is intended to be employed in the Continental trade, and has been fitted with water ballast tank, also all the modern requisites for her destined employment.

A SPLENDID screw-steamer—the largest iron vessel that was ever built at Dundee was launched from the shipbuilding yard of Messrs. Alexander Stephen and Son, on the 25th October. The vessel, which was named the *Cheops*, is 255ft. in length, 33ft. breadth of beam, and 24ft. 5in. in depth and is 1,500 tons register. The engines, which are constructed on the most improved compound principle, are of 150 horse-power nominal, and were manufactured by Messrs. Napier, Glasgow. The vessel is spar decked, and will be schooner rigged.

THERE was launched on the 8th October, from the shipbuilding-yard of Messrs. J. and G. Thomson, at Govan, a handsome screw steamship, of 1,200 tons B.M., for Messrs. Donald Currie and Co., of London and Liverpool. The *Westmoreland* will be fitted with surface condensing compound engines, of 150 nominal horse-power, by the builders. The christening was gracefully performed by Miss Burns, of Upper Dean Terrace Edinburgh, Capt. White being present as representative of the company.

ON the 1st ult., there was launched from the shipbuilding yard of Messrs. Tod and M'Gregor a handsome screw-steamer, 190ft. long by 28ft. breadth of beam, and 722 tons B.M. She is intended for the coasting trade on the island of Cuba, and is built to the order of Messrs. L. Soler and Co., Havana, through Messrs. W. Cruickshank and Co., of this city. The ceremony of naming the vessel the *Clara* was gracefully performed by Miss Marion M,Nab, of Dumbreck Priory, a native of Havana. The engines have been constructed by the same firm, and are on the compound principle, with surface condensation and other recent improvements to secure economy of fuel, and combine simplicity of construction with efficiency of working.

ON the 22th October there was launched from the yard of the London and Glasgow Iron Shipbuilding Company at Govan a screw steamer of 1,500 tons, and of the following dimensions:—Length 252ft.; breadth, 32ft.; depth of hold, 16ft. She is a sister ship to the *Trent*, which was launched recently, and the fifth steamer supplied by the company to Messrs. J. A. Dunkerly and Co., of Hull. She is to be fitted by the builders with machinery of the most improved construction, and will be neatly fitted up for a limited number of passengers. As the steamer left the ways she was named with the customary formalities the *Tiber*, by Miss Clark, daughter of George W. Clark, Esq., Dumbreck.

A NEW iron screw steamship, the *Cambria*, has just been launched form the yard of Messrs. Parfitt and Jenkins, Cardiff. This ship was built for the Cardiff and Portishead Steamship Company, and is intended to ply between Cardiff and Bristol. Her dimensions are:—Length 110ft.; breadth 20ft.; and depth, 9ft. Her machinery is to consist of a pair of condensing steam engines of 40-horse power, and is especially adapted to carrying cargo, while the convenience and comfort of passengers will not be interfered with.

THERE was launched from the shipbuilding yard of Messrs. M'Culloch, Patterson and Co., Port-Glasgow, on the 5th ult., an iron sailing barque, named *Loch Urr*, 734 tons, of the highest class at Lloyd's and Liverpool under-writers' books. This ship is the property of Messrs. D. and J. Sproat, Kirkcudbright, and takes the berth for Sydney, N.S.W., being under charter to Messrs. Aitken, Lilburn and Co., Glasgow.

ACCIDENTS.

A TERRIBLE railway accident is reported from Madras. At a distance of some 130 miles from that city the north-west branch of the Madras Railway crosses the Cheyair by an iron girder bridge of 30 spans of 60ft. each. The girders rest on piers of solid masonry. Heavy rains had swollen the Cheyair, and such was the force of the torrent that several of these piers were completely washed away, the girders disappearing in the river beneath. The night train left Madras at 7 p.m., knowing nothing of what had befallen the bridge, and pursued its way towards Cuddapah and Gooty. Arriving at the broken bridge it plunged headlong into the torrent. It is not yet known how many passengers were drowned. When the train left the terminus the first and second-class carriages were nearly full of passengers. The Cheyair-bridge is situated between the Rajampett and Nundaloor stations (130th to 137th mile) on the north-west line. Happily he train was crossing slowly, else none had escaped, for the depth was great, and the gap tone of 150 yards.

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	s.	d.	To £	s.	d.
COPPER.						
Best selected, per ton	70	0	0	,,	,,	,,
Tough cake and tile do.	68	0	0	,,	,,	,,
Sheathing and sheets do.	71	0	0	72	0	0
Bolts do.	73	0	0	,,	,,	,,
Bottoms do.	73	0	0	75	0	0
Old (exchange) do.	60	0	0	,,	,,	,,
Burra Burra do.	70	0	0	71	0	0
Wire, per lb.	0	0	9½	,,	,,	,,
Tubes do.	0	0	10½	,,	,,	,,
BRASS.						
Sheets, per lb.	0	0	7½	,,	,,	,,
Wire do.	0	0	7	0	0	7¼
Tubes do.	0	0	9½	0	0	10¾
Yellow metal sheath do.	0	0	6¼	0	0	6¾
Sheets do.	0	0	6	0	0	6½
SPELTER.						
Foreign on the spot, per ton.	17	5	0	18	0	0
Do. to arrive.	,,	,,	,,	,,	,,	,,
ZINC.						
In sheets, per ton	22	0	0	22	10	0
TIN.						
English blocks, per ton.	127	0	0	,,	,,	,,
Do. bars (in barrels) do.	128	0	0	,,	,,	,,
Do. refined do.	131	0	0	132	0	0
Banca do.	126	0	0	,,	,,	,,
Straits do.	125	10	0	126	0	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	5	0	1	8	0
IX. do. 1st quality do.	1	12	0	1	14	0
IC. do. 2nd quality do.	1	5	0	1	6	0
IX. do. 2nd quality do.	1	11	0	1	12	0
IC. Coke do.	1	2	0	1	3	6
IX. do. do.	1	8	0	1	9	6
Canada plates, per ton	13	10	0	14	10	0
Do. at works do.	13	0	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	2	6	7	5	0
Do. to arrive do.	7	0	0	,,	,,	,,
Nail rods do.	7	10	0	,,	,,	,,
Do. Stafford in London do.	7	15	0	8	0	0
Bars do. do.	8	2	6	9	0	0
Hoops do. do.	8	15	0	9	0	0
Bars do. at works do.	7	15	0	8	0	0
Hoops do. do.	8	2	6	8	5	0
Sheets, single, do.	9	10	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	0
Bars, common, do.	6	10	0	6	12	6
Do. mrch. Tyne or Tees do.	6	10	0	,,	,,	,,
Do. railway, in Wales, do.	6	0	0	6	0	0
Do. Swedish in London do.	9	10	0	9	15	0
To arrive do.	9	10	0	,,	,,	,,
Pig No. 1 in Clyde do.	2	12	0	3	0	0
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. No. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	17	0	6	0	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pigs in London do.	6	5	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	12	10	0	13	0	0
Do. (hammered) do.	13	0	0	14	0	0
Do. in faggots do.	15	0	0	,,	,,	,,
English spring do.	17	0	0	,,	,,	,,
QUICKSILVER, per bottle	,,	,,	,,	9	9	0
LEAD.						
English pig, common, per ton	18	5	0	,,	,,	,,
Ditto L.B. do.	18	5	0	18	7	6
Do. W.B. do.	19	10	0	20	0	0
Do. sheet, do.	19	0	0	,,	,,	,,
Do. red lead do.	20	10	0	,,	,,	,,
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	22	0	0	,,	,,	,,
Spanish do.	17	10	0	,,	,,	,,

* At the works 1s. to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite Information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

DATED OCTOBER 22ND, 1870.

2785 A. E. Samels—Hooks or fasteners for doors
2786 T. S. Blair—Spiral pumps
2787 J. Worrall—Singeing fabrics
2788 A. Turner—Manufacture of terry or cut-pile fabrics
2789 A. G. Southby—Hollow rolls
2790 W. R. Lake—India-rubber and gutta-percha compounds, &c.

DATED OCTOBER 24TH, 1870.

2791 J. Wilkins—Fixing india-rubber tires to wheels
2792 J. Ellisdon—Improved expanding and contracting canopy
2793 C. E. Miller—Hammering and planishing sheet metals
2794 W. Fox—Grate bars
2795 J. W. Hoffman and H. E. Fearn—Manufacture of the cutting tools used by glasscutters, &c.
2796 B. Blackburn—Inkstands
2797 E. von Jeinson—Automatic lubricators
2798 J. H. Selwyn—Digging tools
2799 W. Firth and J. Eshelby—Fountain lamps
2800 J. Down—Obtaining copper from cupreous pyrites
2801 W. J. Burgess and C. T. Burgess—Reaping machines

DATED OCTOBER 25TH, 1870.

2802 J. C. Bradshaw—Multitubular steam boilers
2803 W. E. Buckland—Permanent way of railways
2804 C. and T. C. Watts—Manufacture of varnishes
2805 B. Hunt—Horse-shoes
2806 B. Dunkerley and R. Eaton—Stretching hat bodies
2807 F. W. Follows and J. Bate—Machines for mincing
2808 W. H. and A. Edwards—Brushes for tube cleaning
2809 W. Richards—Firearms
2810 J. J. Lundy—Compound for the lubrication of wool, &c.

DATED OCTOBER 26TH, 1870.

2811 W. Hill—Beating carpets
2812 W. E. Gedge—Rolling mills, &c.
2813 W. G. Reeve—Scientific fountain
2814 W. Bywater and J. Shaw—Machinery for drawing flax, &c.
2815 A. Hawkins and C. Pickering—Knife-cleaning machines
2816 F. Burney—Pebble gunpowder
2817 B. Adams and G. H. Greenwood—Horse-shoes

DATED OCTOBER 27TH, 1870.

2818 J. S. Crosland—Steam boilers
2819 J. Westray—Moulding apparatus for cast-iron ingots, &c.
2820 E. T. Hughes—Outlet or jet pipes of fire engines, &c.
2821 R. Lees—Low-water alarms for steam generators
2822 S. B. Bush—Preventing the entrance of flies into rooms
2823 P. Spence—Sulphuric acid
2824 J. H. Anderson—Soap
2825 W. Riddle—Pencil cases
2826 W. Ross—Ball valves
2827 R. Brewitt—Calendering and other pressing machinery
2828 J. Gamgee—Automatic vendor
2829 W. R. Lake—Springs for railway carriages
2830 R. P. Dawson—Slide rests
2831 J. G. Willans—Preparation and use of peat, &c.
2832 W. F. Sweetland and J. Merfield—Purifying sewage
2833 F. Ryland—Shaping sheet metal
2834 H. Boughton—Fog signals
2835 A. Bennett—Mechanism for giving a slow rotatory motion to the bottoms of ovens
2836 E. Field and R. M. Merryweather—Steam fire-engines

DATED OCTOBER 28TH, 1870.

2837 W. Gadd and J. Moore—Small-ware looms
2838 J. J. Hays—Treating sewage
2839 H. Crook—Umbrellas
2840 A. H. Hart—Appliances to be attached to cotton reels
2841 E. Sunderland—Corkscrews
2842 J. Rennie and T. Halliday—Boiling worts, &c.
2843 H. Bollack—Umbrellas
2844 J. Gough—Presses for relief stamping or printing
2845 R. Herring and R. A. Novare—Telegraphic printing apparatus

DATED OCTOBER 29TH, 1870.

2846 A. Long—Controlling the passage of water, &c.
2847 R. Hornsby and J. E. Phillips—Ploughs
2848 W. J. Osborne—Travelling wrappers
2849 J. C. Haddan—Street railway carriages, &c.
2850 J. Tyrer—Brace buckles
2851 A. Lafage—Camp bed
2852 R. B. Turner and J. Welch—Needle cases
2853 J. Vero—Hardening felt hat bodies
2854 J. Robertshaw—Combing wool

DATED OCTOBER 31ST, 1870.

2855 J. Roberts—Bridges, &c.
2856 G. W. Dyson and H. A. Hall—Rolling circular metal
2857 T. S. Blair—Spiral pumps
2858 J., J., J., H., and C. W. Hawkins and J. Cuerdale—Mules for spinning
2859 H. Bradford—Ore-washing machines
2860 W. S. Wetmore—Protecting troops under fire
2861 J. A. Newnham—Preservation of milk
2862 W. R. Lake—Looms for weaving
2863 W. E. Newton—Silicious compound
2864 J. B. Spence—Preparation of manures from tribasic phosphates
2865 A. H. Brandon—Producing the more complete combustion of gas
2866 J. H. Johnson—Acids, &c.
2867 R. Punshon—Gun cotton
2868 J. Brooks—Bushes of pulley blocks for ships

DATED NOVEMBER 1ST, 1870.

2869 A. Ballantyne—Manufacture of malleable iron, &c.
2870 W. Hammant—Instrument for cutting off the ends of boiled eggs
2871 W. Dawes—Steam engines
2872 A. M. Silber and F. White—Apparatus for lighting
2873 R. Walker—Artificial fuel
2874 J. Woodcock and J. Coulter—Indigo blue dyeing
2875 A. C. Sterry and J. Sterry—Purifying oils
2876 W. E. Newton—Improvements applicable to safes, &c.
2877 J. Vero—Felt hats
2878 S. Tuddenham—Metal gates, &c.
2879 J. H. Johnson—Boxes and bearings for axles
2880 T. Baker—Boots
2881 F. Hunt—Trousers protector

DATED NOVEMBER 2ND, 1870.

2882 A. McNeile and J. Slater—Wheels of vehicles
2883 T. Saunderson—Leather laces
2884 O. Trossin—Motive power
2885 G. Hatton—Mechanism for venetian blinds
2886 J. N. Lessware—Drying machines
2887 T. Brooks—Postal wrappers
2888 R. J. Hilton—Tobacco
2889 W. Henderson—Treating cast iron
2890 A. M. Clark—Motive power
2891 R. Reece—Apparatus for cooling and refrigerating liquids
2892 U. K. Mayo—Dentistry
2893 P. Combaluzier—Chassepots and other similar rifles

DATED NOVEMBER 3RD, 1870.

2894 R. Bewley and I. Cotton—Machinery for grinding
2895 R. J. Goodbody and M. J. O'Farrell—Roll tobacco
2896 J. Jones and H. B. Fox—Raising and lowering windows
2897 C. Wheatstone and J. M. A. Stroh—Telegraphs
2898 J. Howard and T. Phillips—Improvements in ploughs
2899 W. E. Newton—Pointing nails
2900 A. V. Newton—Cutting stone, &c.
2901 H. Armitage—Padded quilts
2902 F. T. Stokes—Bedsteads
2903 J. Breedon—Taps or valves
2904 S. Oran—Tilling land
2905 W. R. Lake—Pneumatic telegraphs
2906 T. A. Dillon—Utilising the waste steam of steam engines
2907 A. M. Clark—Firearms
2908 A. M. Clark—Advertising

DATED NOVEMBER 4TH, 1870.

2909 P. Brotherhood—Boilers
2910 T. Richardson, J. W. Richardson, and A. Spencer—Rails
2911 J. Griffits—Imparting elasticity to leather, &c.
2912 J. Emmott—Preparing wool for combing
2913 F. F. Jones—Puddling furnaces
2914 F. B. Fawcett—Carpets
2915 J. Somerville—Improvements in pipes
2916 E. Walker and W. Clarke—Windlasses
2917 H. Macaulay—Firearms
2918 C. W. Meiter and T. W. Smith—Tapping barrels

DATED NOVEMBER 5TH, 1870.

2919 N. S. Walker—Lead pipes, &c.
2920 W. Morgan—Roofs
2921 E. V. Neale—Mechanical cypher
2922 W. H. Tooth—Furnaces
2923 J. W. Kenyon—Steam boilers
2924 W. R. Lake—Buoyant mattress
2925 J. G. Tongue—Axles of railway and tramway carriages
2926 G. D. Nicol—Sail cloth
2927 W. Low—Machinery for tunnelling
2928 G. Dominy—Turning the leaves of hooks

DATED NOVEMBER 7TH, 1870.

2929 J. Bailey—Lifting apparatus
2930 R. Boyd—Tracing patterns
2931 David Lang—Tell-tale apparatus
2932 J. Clayton—Cropping textile fabrics
2933 W. H. Maitland and W. L. Maitland—Registering the money taken at theatres
2934 A. M. Clark—Cutting lozenges
2935 W. E. Newton—Metallic composition
2936 A. V. Newton—Treadles

DATED NOVEMBER 8TH, 1870.

2937 E. J. Jones—Grinding saws
2938 I. Baggs—Smelting metals
2939 A. M. Clark—Carpet lining
2940 J. Henderson—Refining cast iron for foundry purposes
2941 H. Walker—Apparatus for drying
2942 W. Thomas and W. Rothwell—Machinery for washing wool
2943 W. E. Newton—Extracting the useful substance of hops
2944 H. C. Symons—Advertising
2945 J. Broadley—Coupling railway carriages, &c.

DATED NOVEMBER 9TH, 1870.

2946 J. Dorrell and J. F. Rudge—Slabbing iron
2947 M. Alex—Lowering boats
2948 W. V. Wallace—Surfaces for painting
2949 N. Jarvie, W. Miller, and W. Calderwood—Furnaces
2950 B. Hunt—Securing screw bolts
2951 W. R. Lake—Effecting the supply of the deodorising material in earth closets
2952 W. J. Cockburn-Muir—Permanent way of tramways
2953 T. J. Smith—Sewing machines

DATED NOVEMBER 10TH, 1870.

2954 J. A. and J. Hopkinson—Safety valves
2955 W. Higgins—Street indicators
2956 T. H. Simmonds—Boxes for furs
2957 J. Ronald—Machine for forming strands, &c.
2958 W. H. Gittins—Turning wheat, &c.
2959 E. P. H. Vaughan—Gas engines
2960 T. G. Webb—Articles of pressed glass
2961 B. Lockwood—Padded quilts
2962 T., J., and F. Cooper, and J. Ogden—Looms
2963 A. M. Silber and F. White—Lamps

DATED NOVEMBER 11TH, 1870.

2964 W. E. Gedge—Steam machine for agricultural work
2965 W. A. Gilhee—Water meters
2966 E. Bolton—Crucibles, &c.
2967 M. and G. F. Dawson—Spinning fibrous substances
2968 T. Hart—Improvements in self-acting mules
2969 E. Herring—Manufacture of alkalised isinglass, &c.
2970 S. Tuddenham and A. R. Eyre—Ornamental work in glass, &c.
2971 F. Brampton—Holders and port-folios for holding or filing music, &c.

DATED NOVEMBER 12th, 1870.

2972 R. P. Pearn and F. K. Pearn—Raising and forcing fluids
2973 J. Chrimes—Railway carriages and other road vehicles
2974 A. G. V. Harcourt—Purification of gas
2975 A. F. de Hemptinne—Concentrating sulphuric acid
2976 M. Williams and J. Lamb—Lubricating compounds
2977 J. Page—Making moulds
2978 I. Jacobs—Penholders and pens
2979 R. Fry—Manure from blood, &c.

DATED NOVEMBER 14th, 1870.

2980 C. Golden—Breech-loading guns
2981 R. Hill, A. T. Ward and C. F. Claus—Wire, &c.
2982 W. T. Tongue—Lamps
2983 G. H. Smith—Sewing machines
2984 W. Ord—Rivets
2985 G. E. Donisthorpe—For registering
2986 J. Davidson—Gunpowder

DATED NOVEMBER 15th, 1870.

2987 J. Somervell—Casks, &c., water-tight
2988 A. Chamberlain—Castors for furniture
2989 J. S. Smyth—Tents
2990 T. Dawson—Fire-igniter
2991 J. Brunton—Meters for water
2992 J. Shannon—Lowering turrets
2993 T. Hitchcock—Motive power

DATED NOVEMBER 16th, 1870

2994 T. Williamson Indicators for Engines
2995 W. Martin—Movable weirs
2996 T. Henderson—Textile fabrics
2997 J. Landless—Preventing over-winding
2998 H. Belmont—Machinery for tiling
2999 J. H. Spencer—Water closets
3000 H. Lyon—Apparatus for weighing
3001 G. Haseltine—Compressing metals
3002 I. Rheinberg and N. Rheinberg—Pen holders
3003 J. H. Bass—Vessels for making coffee
3004 J. Carter—Scissors, &c.
3005 G. Haseltine—Electro-plating iron, &c.

DATED NOVEMBER 17TH, 1870.

3006 J. Welch—Needle cases
3007 A. Cutthell—Cleaning, &c.
3008 H. Wallace—Furnaces
3009 J. Pickering—Raising weights, &c.
3010 M. Dodds—Cork cutting knives
3011 W. Taylor—Sewing machines
3012 J. Collins—Constructing fringes
3013 R. B. Hughes—Road rollers
3014 C. F. Bower—Invalid bicycle
3015 E. A. Pontifex and J. Barton—Centrifugal machines
3016 G. Haseltine—Safes, &c.
3017 G. F. Deacon—Automatically supplying fuel to furnaces
3018 G. Haseltine—Steel horse shoe nails

DATED NOVEMBER 18TH, 1870.

3019 G. C. Wilson—Cartridge cases
3020 J. Galletly and W. MacIvor—Treating hydrocarbons, &c.
3021 J. Frölich—Furnaces
3022 T. Drummond—Exhibiting advertisements
3023 R. Hipkiss—Hardening steel pens
3024 J. Grindrod—Boiler feeding apparatus
3025 T. Mills and W. Bryce—Steam generators, &c.
3026 W. Cunningham—Lubricating apparatus, &c.
3027 R. P. Wilson—Testing oils
3028 H. Y. D. Scott and G. R. Redgrave—Mixing selenitic mortar
3029 A. Ransome—Cutting wood

DATED NOVEMBER 19TH, 1870.

3030 C. Axon—Working railway signals
3031 G. Duncan and W. A. Wilson—Folding, &c., paper from printing machines